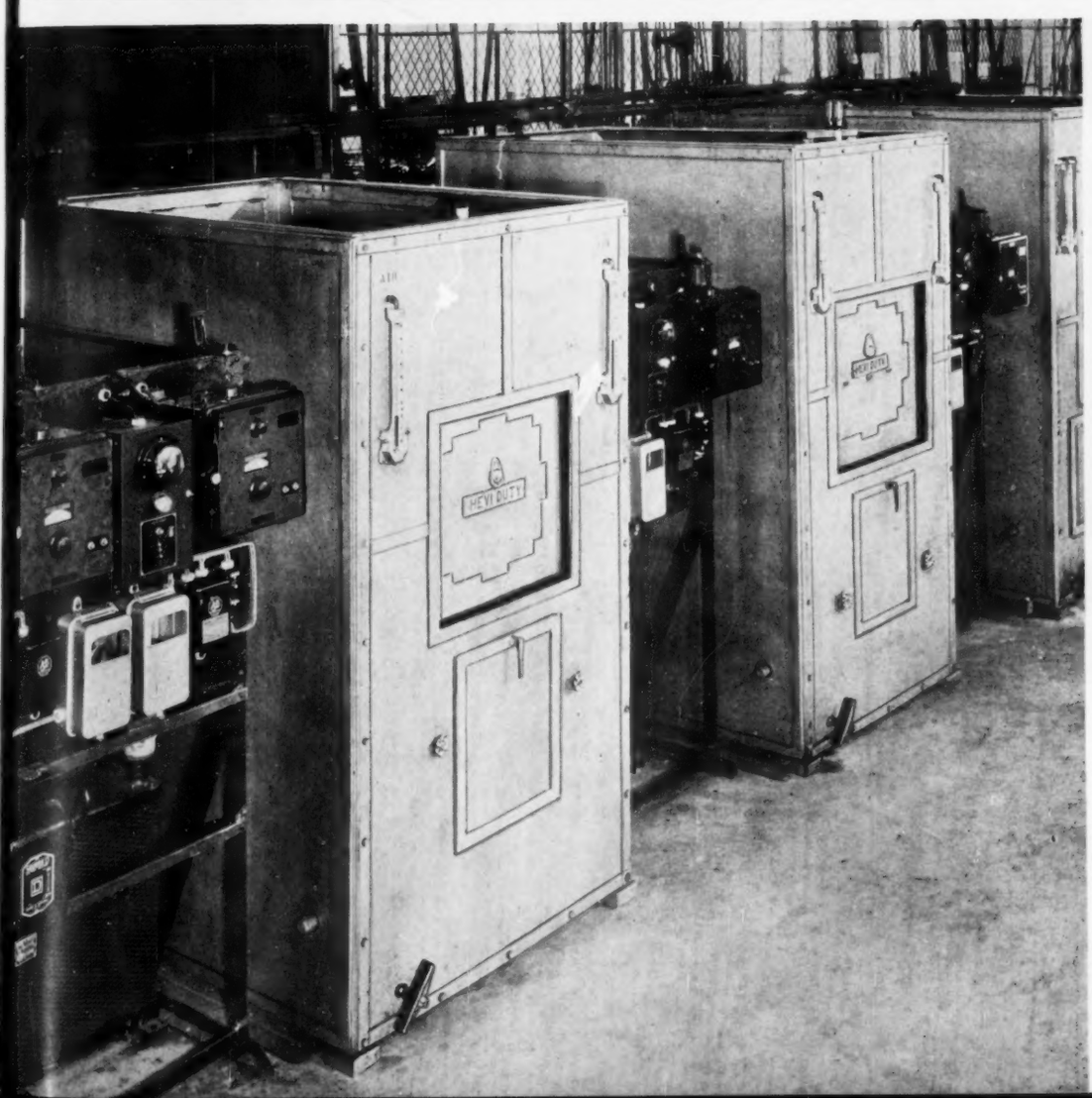
INSTRUMENTS

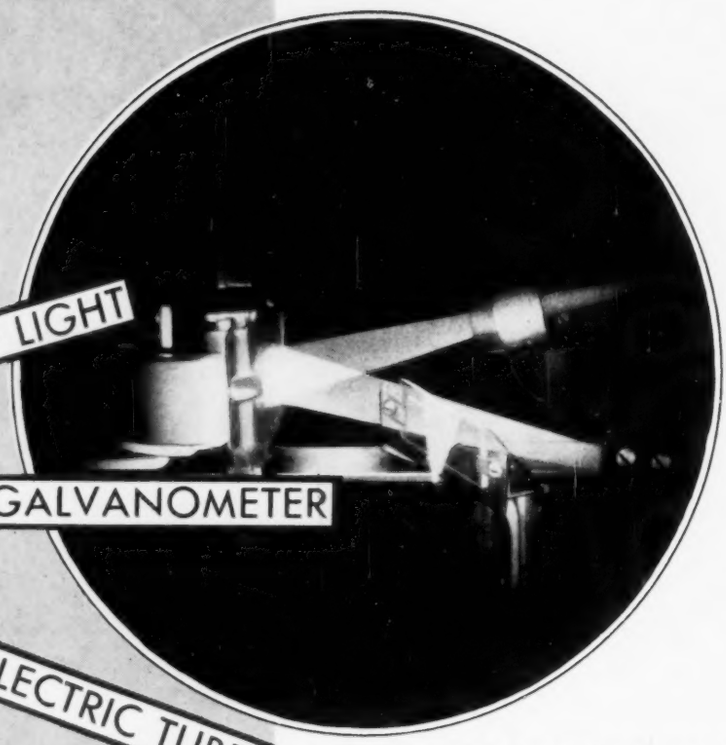
THE MAGAZINE OF MEASUREMENT and CONTROL



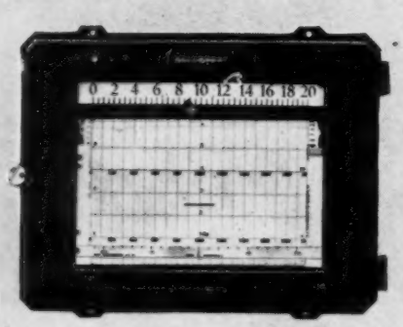
VOLUME 10

OCTOBER 1937

NUMBER 10



TAG CELECTRAY PYROMETERS HAVE PROVED THEIR VALUE IN



. . . because they have sponsored rugged industrial instruments unequalled in sensitivity, speed and adaptability.

In TAG CELECTRAY Pyrometer design, recording accuracy is maintained not only because these Pyrometers are accurately calibrated as electrical instruments, but because the TAG method of photoelectrically balancing a potentiometer or Wheatstone bridge is precise. Recording is accurately repeated even in a recently announced high-speed CELECTRAY Recorder which will handle as many as twelve records in a little over one minute . . . balancing error a few hundredths of one percent.

Ask for full details of the complete line of TAG CELECTRAY Pyrometers especially suited for dependable service in industry . . . There are models for Recording, Indicating and Controlling which stand in a class by themselves for superiority in combined high speed and precision. Send for your copy of Catalog No. 1101-I which describes these CELECTRAY Pyrometers fully.

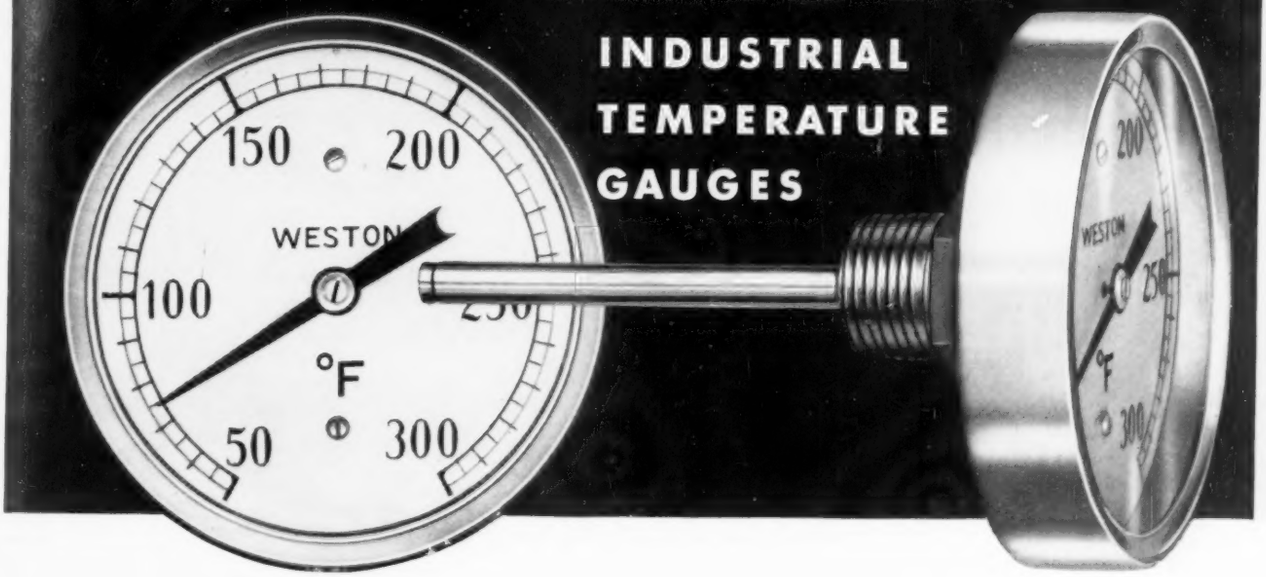
C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

TAG LIABUE BROOKLYN N.Y. U.S.A.

New! WESTON *(ALL METAL)*

INDUSTRIAL TEMPERATURE GAUGES



Sectional view showing operating parts of WESTON *Industrial Temperature Gauge*

1. **New, scientific principle of temperature indication . . . all metal operating element . . . no glass, no fluids.**
2. **Accuracy of 1% over entire scale.**
3. ***No damage from over-temperatures or severe vibration.***
4. **Quick, smooth response to temperature changes.**
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6. **Easy to read . . . easy to install . . . standard stem lengths to 24" . . . ranges up to 1000° F.**

Operating on a new but thoroughly proved principle which provides sustained accuracy and easy readability, and which eliminates breakage from over-temperatures, the new WESTON industrial temperature gauges are finding wide application throughout all industry for the usual as well as many unusual temperature indicating requirements. Complete information is available. Communicate with the nearest WESTON representative, or, send coupon for literature.

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Weston Electrical Instrument Corporation
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Send complete information on WESTON Thermometers.

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

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INSTRUMENTS The Magazine of MEASUREMENT and CONTROL

M. F. BEHAR
EDITOR

IN THIS ISSUE

Again the Forest Products Laboratory contributes to the American people — through *Instruments* — a new (but already highly-developed) instrument. This time it is a novel vacuum-tube resistance bridge — which I. I. Davies describes in this month's first feature article. Page 261.

Again Professor Williams states novel points of view on relatively old devices—in concluding his treatment of "recent" scratch hardness methods. Page 265. Yes, he will discuss *modern* scratch hardness methods beginning next month.

Again it is *Instruments*' rôle to publish for the first time an arduously compiled table of characteristics of a class of instruments. R. R. Batcher has just completed one relating to the cathode-ray tubes on the market. Page 267.

Again the Instrumentation Forum contains not only the proposed solutions of an unusual problem but also the statement of another unusual problem. Page 268.

And again the month's crop of new instruments sets a new high for the year: twenty-two columns—more than thirty items—approximately forty different new devices. Pages 250-260.

But no matter how useful we try to make each of the remaining issues of Volume Ten, they seem unimportant in comparison with one that is beginning to take shape.

THE FRONT COVER

shows another of those impressive rows of furnaces—impressive because all are equipped with modern individual control panels. It was submitted by the C. J. Tagliabue Mfg. Co., which got it from the Hevi-Duty Electric Furnace Co., which took it at the American Brass Co., Waterbury, Conn.

TENTH ANNIVERSARY PLANS

An intimate message from RICHARD RIMBACH, Publisher

SINCE the first issue of *Instruments* came off the press in January 1928, there have been tremendous advances in the fields to which it is devoted:

—in the useful *applications* of instruments, meters, automatic controllers, inspection and testing devices, etc., throughout industry;
—in the diversification of these products, in their standardization and in their quality;
—in the formulation of the theories underlying proper selection and correct application of these products;
—in "the recognition of Instrumentation as a distinct branch of engineering and as a distinct field of scientific management"—even by some groups jealously antagonistic in the past (but now scrambling to climb on the band-wagon);
—in the publication of *authoritative texts* on the several distinct branches of Instrumentation;
—in the organization and management of *instrument departments;*
—in the *training* of instrument apprentices, instrument engineers, etc.;
—in the *influence* and *standing* of instrument men, whatever their official titles may be;
—in the *economic status* of all instrument men, from young instrument apprentices to instrument-minded high executives whose titles do not include the word "instrument";
—and in the manifold blessings to civilization brought about both directly and indirectly.

As you know, this progress is largely due to the pioneering efforts and creative work of a "circle" including not only *Instruments*' editorial staff but hundreds of advisers, authors, collaborators and correspondents in all industries, in all branches of science and technology. Yesterday this circle put Instrumentation "on the map." Today it is doing more for the profession than all other friendly influences, and it is defeating unfriendly influences. Tomorrow this *ever-widening* circle will function even more efficiently, even more *purposefully* . . .

Meanwhile, it is proper that our coming tenth anniversary be an occasion for publishing reviews, analyses, forecasts, useful compilations, etc. Accordingly, our January 1938 issue will comprise fourteen sections, bound in two parts (see Page A9)

Because of the permanent reference value of this January number, the demand for copies will be enormous. A publisher, however, cannot take chances. There is no national association ready to make up our loss if we print 30,000 and sell 15,000. Therefore, we shall print just enough for *subscribers on our books* and paid-in-advance orders, plus the usual copies to authors, advertisers, etc. Thousands of engineers, executives and research men are going to be disappointed—especially wherever there is only one company subscription and a number of individual readers. If you are merely on your company's route slip, you will probably be out of luck. See to it that a group subscription is sent. Use the form on page A9.

While I "have the floor" I want to remind you that there are two kinds of editors. One is a "scissors-and-pastepot-editor." He takes the material as it comes to him, questions little, edits less—and has it set in type. Then with scissors and paste he puts together a magazine, a creditable one perhaps, though its content has not improved by his having worked with it. The other is a creative editor. He studies, questions, edits, polishes and correlates the copy that comes to him. The individual manuscripts, when he finishes with them, are better, smoother, less wordy, more thorough, easier to read. He makes the reader's work easier for him. Perhaps you can identify magazines edited by these different types of men.

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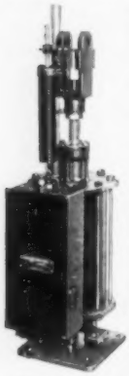
Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

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NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions.

When writing to manufacturers directly, please mention this department as your source of information.

Or write to Information Section, Instruments Publishing Company.

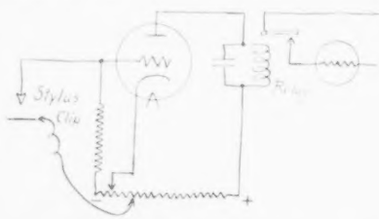
"Bioptical" Pyrometer

This is a new "combined color" pyrometer employing a measuring principle based on the use of light filters and color wedges said to be transparent to a num-

ber of colors simultaneously. By using filters with a number of transparencies both for separation and for mixing and toning down, a simple temperature measuring device in the form of colored disks is rendered possible. New "Bi-Optical" pyrometer is said to permit the black-body temperature and the actual temperature to be "ascertained simultaneously." Instrument is furnished with scale ranges from about 900-1900°C. or 1700-3500°F., may be used for laboratory and research applications including ferrous alloys in the open, flame heated furnaces, etc.—*The Pyrometer Instrument Co., 103 Lafayette St., New York City.*

Electronic Paint Thickness Gage

For measuring thickness of paint film on metal objects, new "Bathytrol" employs a modification of the penetration method whereby an electric circuit is



closed and a light flashed when a stylus comes in contact with metal below paint film. Instead of lamp-lighting current flowing through stylus (which is said to be a source of considerable error because of great variations in small-area high-resistance contacts between stylus point and metal) only a triode-grid current is required to flow through stylus; a few microamperes at a few millivolts suffice to shift tube grid to positive, so that plate circuit energizes a telephone type relay (requiring a few milliamperes) which in turn closes lamp circuit. Apparatus comes complete in carrying case, ready for use on flat, curved or irregular surfaces. The only parts subject to wear are a standard tungsten steel phonograph needle and a radio tube.—*Electronic Control Corp., 2632 East Grand Blvd., Detroit, Mich.*

Improved "Rotameters"

Complete line of flow-rate indicators, recorders, controllers and telemetering systems with "Rotameter" variable-area class, float type, primary elements (see numerous news items in *Instruments* since 1931) is now available from new company devoted exclusively to the manufacture of the primary elements and to the assembly of complete systems (embodying electrical and other components obtained from American instrument companies). Development and installation of special machinery for the manufacture of primary elements in the U. S. A. has not only ended troubles previously arising from dependence on Germany, but has resulted in the production of interchangeable parts heretofore unavailable. It is furthermore claimed that this interchangeability is made possible by the introduction of American precision methods, so that users no longer need recalibrate meters and controllers whenever an essential element has to be replaced following accidental breakage or other cause. Among other improvements in new precision tubes are permanently-fused graduations.—*Fisher & Porter Co., 110 W. Penn St., Germantown, Philadelphia, Pa.*

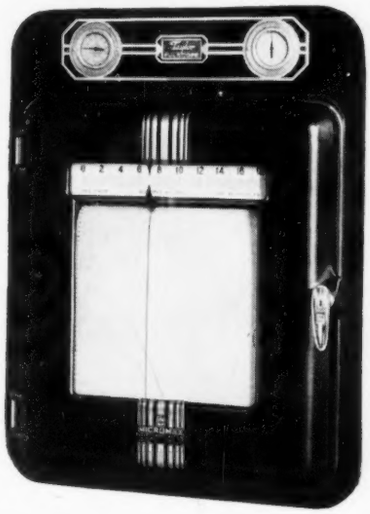
Small-angle All-range Acoustic Pick-up

Highest degree of directional selectivity, without sacrificing important portions of the audio-frequency spectrum, is accomplished by assembly of graded

tubes combining (1) "pipe organ" principle for spectral width and (2) "target rifle" principle for angular narrowness. Non-technical photograph (use at Am. Legion parade broadcast) is purposely selected as illustrating "focusing" on one source of sound surrounded by others.—*Western Electric Co., 195 Broadway, New York City.*

Air-operated Control Potentiometer

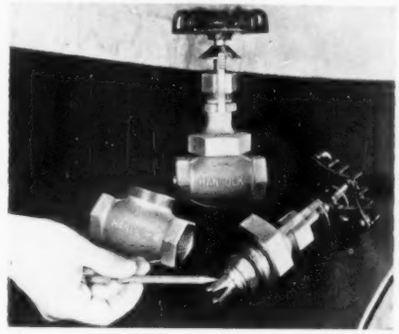
For process control applications where smooth proportional valve action is imperative and the potentiometer principle of temperature measurement is preferred, the "Fulscope Micromax Air-operated Potentiometer Controller" is announced. It utilizes the "Fulscope" completely-adjustable air-operated control mechanism (see *Instruments*, April 1934, page 81). Its temperature measuring system is the L. & N "Micromax" recording and indicating potentiometer (see *Instruments*, Sept. 1931, page 505) in which all functions affecting accuracy of temperature measurement — reference-junction compensation, balancing of the potentiometer circuit and current standardization—are completely automatized. Interchangeability of principal parts of both mechanisms with the Fulscope and Micromax instruments now in service makes for small



stocks of replacement parts and better service. Fulscope control unit operates in conjunction with the Taylor "Motosteel" diaphragm valve (see *Instruments*, June 1936, page 156). For applications where precision valve action, or both precision valve action and compensation for changes in load, may be necessary, the Fulscope control mechanism can be supplemented with the Taylor "Valv-Precisor" (*Instruments*, Nov. 1935, page 314) or "Dubl-Response" control unit (*Instruments*, May 1933, page 112), respectively. Thus, it is said, control equipment most economically solving individual control problem may be selected.—*Taylor Instrument Companies, 95 Ames St., Rochester, N. Y.*

Redesigned Valves

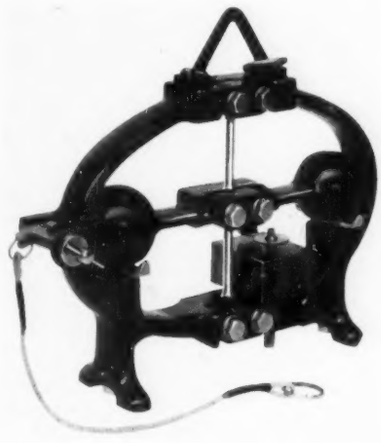
Completely redesigned "Flocontrol" valves are said to be "a combination flow instrument and shutoff valve." They retain straight-line flow characteristic of the original valve. "Superhard" stainless-steel seats and disks (500 Brinell) have to be made on diamond boring machines. New valves have an entirely new body of union bonnet type instead of the inside screw bonnet originally used, are suitable for such applications as temperature control for gas-fired, oil-fired or steam-heated processes; for proportional blending of liquids, water softening systems, oil burner lines, continuous boiler blow-down, etc.



Also announced is the "Hancock Duravalve," with internal Stellite seats, developed expressly for high-pressure high-temperature service (1500 lbs./in.^{2} at 950°F.), claimed to put an end to valve maintenance due to steam leaking between valve seat ring and valve body. New design permits Stellite seat facing to be easily welded in and serviced even on small sizes. "Duravalves" are made in one basic size and then tapped, or bored for welding, for $\frac{1}{2}$", $\frac{3}{4}$" or 1" pipe.—*Hancock Valve Division, Manning, Maxwell & Moore, Inc., Bridgeport, Conn.*

Torsional Damping Testing Machine

Designed for determining the internal damping capacity of materials being considered for important uses such as crank shafts, etc., new Torsional Damping Recorder can be used for testing steel, aluminum, phenolic materials, etc. It takes a test piece shaped into a rod (seen vertical in photograph), which is twisted 0.0039 radians and then let go. Oscillations are automatically recorded by the stylus-on-celluloid method. Each test record, together with the known di-



mensions of the specimen and constants of the machine, gives complete data from which it is relatively easy to compute not only the material's damping capacity but other properties.—*Cambridge Instrument Co., Grand Central Terminal, New York City.*

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THE
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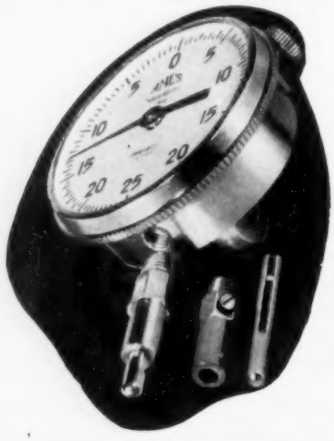

EASILY CLEANED

The case stem of the Ames Shockless Gauge can be easily unscrewed, the lower half of the spindle withdrawn for cleaning and the assembly replaced without otherwise disturbing the gauge. For details of other exclusive features, send for the Ames Gauge catalogue.

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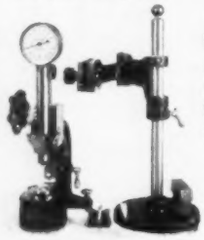

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The Shore Instrument & Mfg. Co., Inc.
9025 Van Wyck Avenue, Jamaica, N.Y.

Pyrometer Controller

"Alnor" Pyrometer Controller for heat-treating furnaces, melting pots, etc., employs a contact-less principle of operation: pointer of indicating pyrometer

carries a small vane, and an adjustable target carries two vanes which are the capacitive element of a tuned circuit. When pointer approaches temperature setting, vanes of pointer and target interleave and produce a circuit change whereby a relay is operated. There being no direct contact between the vanes, pointer is always free to give continuous indication and control. A red bull's eye indicates whether furnace heat is on or off. All circuit elements are operated considerably under rating. Should tube burn-out occur, furnace is automatically shut off. Tubes are obtainable from radio tube dealers. Tube replacement does not always necessitate re-tuning instrument. For electric furnace operation, metallic mercury switches are available in sizes up to 35 amps. at 110 volts a.c. For higher ratings a separate circuit breaker is necessary. For fuel-fired applications, solenoid or motorized valves are energized. The pyrometer movement is "Type 2860" Horizontal Edgewise. (*Instruments*, August 1935, page 219). Standard temperature ranges 0-300, 0-400, 0-500, 0-600, 0-800, 0-1000, 0-1200, 0-1600, 0-2000, 0-2500, 0-3000 degrees F., or C. equivalent, hand-calibrated for iron-constantan, chromel-constantan, chromel-alumel, platinum-platinum 10% or 13% rhodium, depending on equipment and range.—*Illinois Testing Laboratories, 420 N. LaSalle St., Chicago, Ill.*

Universal-swivel Indicators

Three new models of the "Universal Test Indicator" brought out a few months ago (*Instruments*, July 1937, page 174) are announced, making available the following line:

Model	*Graduations*	*Range*
1	0.001"	0.03"
2	0.0001"	0.008"
3	0.005mm.	0.2mm.
4	0.01mm.	0.8mm.

All four are externally alike except for the dial graduations.—*Federal Products Corp., 1144 Eddy St., Providence, R. I.*

Sealed Thermal System Thermometers

Thermal system of new "Mono-therm" indicating and recording thermometers completely and permanently seals the actuating medium, being either welded or brazed into one piece of metal (whence "mono"), remains tight in spite of mechanical shocks, continued vibration, and overrange temperatures. New construction is at present being applied to vapor-pressure, gas-filled and liquid-filled classes. By means of new extra overrange

protection, liquid-filled recording instruments can be protected against an overrange up to a maximum of 500°F.; gas-filled recorders can be protected against an overrange of 100% up to a maximum of 1000°F.; vapor-pressure recorders can be protected for a 100% overrange "to the breakdown point of the actuating medium." Bourdon spring of vapor-pressure indicating thermometer has been made wider; movement large and stronger. The gas-filled recording thermometer also employs a new wide spring which increases its power.—*The Foxboro Co., Foxboro, Massachusetts.*

Water Circulator

To speed up circulation on hot water heating systems, this new device may be used alone or in conjunction with an M-H Flow Valve to provide fully automatic summer-winter hot water control. Water Circulator is quiet in operation, leak-proof by reason of M-H Packless Seal, standard with built-in thermal overload cut-out, has a high starting torque, offers no radio interference, has stainless steel drive shaft and bronze bearings. Sizes to fit 1", 1½", 2" and 3" pipe mains. Although 110-volt 60-cycle motors are standard, Circulator is available for 220-volt 60-cycle and 110- or 220-volt 25, 30, 40 or 50 cycles, or for 115- or 230-volts d.c.—*Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

"Dairy" Scale-range Thermometers

A new line of thermometers is announced, all of the "industrial" construction and all for industrial applications below 212°F. as typified by dairies, creameries, etc. New models in line include multiple-purpose instruments with the scale cases illustrated. These meet all Federal, state and local health regulations; make it possible to read cooling, aging and pasteurizing temperatures on one instrument; em-

Fig. 1

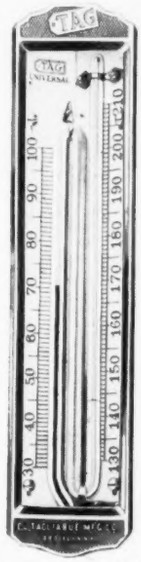
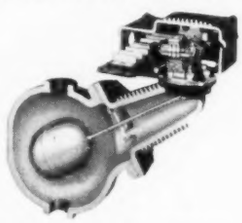


Fig. 2

body 'TAG Red Reading Mercury Column"; and have single-degree divisions not more than 16 per inch. Fig. 1 shows uniform-bore-tube thermometer with 13" scale having cooling range graduations at right and pasteurizing range at left. Fig. 2 shows "universal scale" thermometer: a 12" scale in a 7" scale case. Each is available with various stem arrangements.—*C. J. Tagliabue Mfg. Co., Park & Nostrand Aves., Brooklyn, N. Y.*

Boiler Control Unit

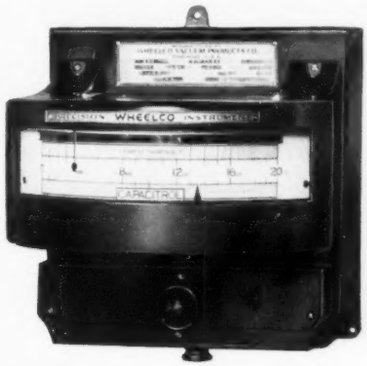
Designed for steam pressures up to 150 lbs./in ², this new boiler control unit is a combination pump control and low water cut-off. These two controls have distinctly separate operating levels, and the differential between the two circuits is adjustable, as is also the differential between the off and on operation of the controls. A flexible metallic bellows



transmits float power to the outside switch mechanism, without stuffing boxes. Pump control circuit commands boiler feed pump in accordance with requirements of boiler. At a lower level, a second circuit will shut off the oil burner or stoker in case of a fuse failure in the pump circuit.—*McDonnell & Miller, Wrigley Bldg., Chicago, Ill.*

Pyrometer Controller

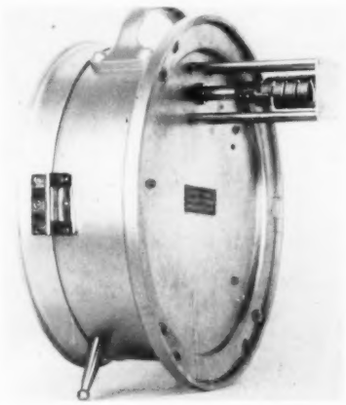
Designed for fuel-fired or electrically heated applications which cannot be successfully controlled by 2- or 3-position systems, new "Proportioning Capacitrol"



is a modification of original Capacitrol (see *Instruments*, Nov. 1935, page 304). It provides a throttling or proportioning mode of control by regulating the ratio of *on* time to *off* time in a time cycle of predetermined duration. "The length of the cycle has been chosen sufficiently small so that the change in temperature is practically negligible," it is said. This continuously-repeating time-cycle mode is supplemental to direct control of fuel supply: it comes into play as the furnace or oven temperature approaches the setting point. "Contactless" operating principle is similar to that of original Capacitrol: pointer of indicating pyrometer is free at all times and commands the control mechanism by its position with respect to tuned-circuit elements.—*Wheelco Instruments Co., 1933 S. Halsted St., Chicago, Ill.*

Traveling Type Oven Temperature Recorder

For use in baking, finishing and enameling ovens, etc., a traveling type recording thermometer passes through the oven on the conveyor with the work,



thereby producing a record of the temperatures to which the work is subjected. Among applications are ovens for treating the finish on automobile bodies: records serve as guides to proper temperature for color of finish desired. The new portable recording thermometer records on an 8" round chart for 24-hour or 7-day clock rotation.—*The Bristol Co., Waterbury, Conn.*

'MEGGER' *Presents*—

a new and unusual type of portable ohmmeter for the man who needs something definitely better than instruments heretofore available—something more dependable, more accurate, with which to measure resistance in coils, contacts, circuits, relays and other equipment.

The MIDGET "MEGGER" CIRCUIT TESTING OHMMETER is a true "Megger" Cross-Coil Ohmmeter (not just a voltmeter calibrated in ohms). It requires no adjustment for battery voltage. Has remarkably wide ranges—from .1 ohm to 200,000 ohms. Has remarkably low ranges—0 to 3 ohms full scale, reading to .02 ohm. Built to "Megger" standards of accuracy, ruggedness and durability.

Write for descriptive Bulletin 1495-I.

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The Burling
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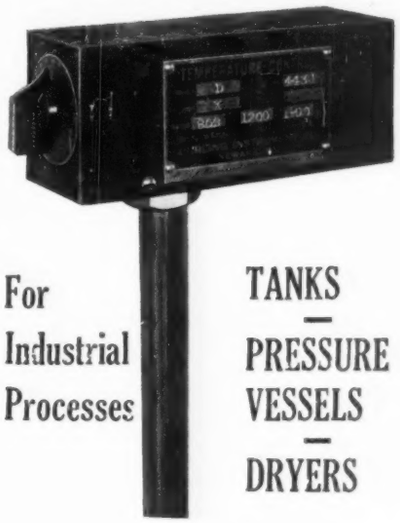

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50°-1400° F.

A rugged and accurate instrument that is easily installed in ovens or tanks with suitable fittings. Tubes of non-corrosive alloys. Coming soon—TWO STEP CONTROL—Watch for announcements.

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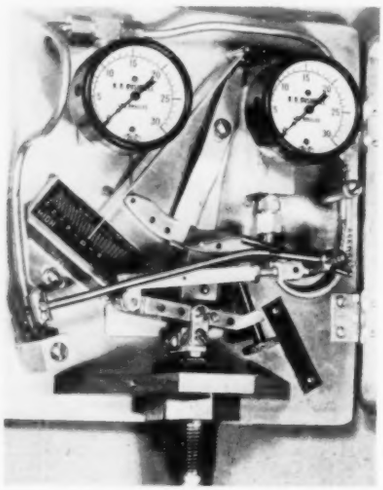
Burling Instrument Company
239-243 Springfield Ave. Newark, N. J.

Indicating Model of Temperature Controller

"All Range" bi-metallic rigid-stem air-operated temperature controller (see *Instruments*, August 1936, page 216) may now be obtained with a pointer-and-



scale arrangement whereby departures from setting-point are indicated on a zero-center type scale covering a total range of 40°F. and visible through a window in cover. Though calibrated in degrees plus and minus, "Variation Indicator" arrangement is not inherently a thermometer but a guide to controller performance: pointer is adjusted to zero when temperature of controlled application (as measured by other means) is exactly at control point. Should it be desired to hold the same application at another temperature more than 20° higher or lower, or should it be desired to transfer entire controller to another application where a different temperature is to be held, re-setting of pointer on zero is similarly effected.—*B. O. Bushnell, 541 North Kings Road, Los Angeles, Calif.*

Superpressure Gage and Pump

Two major items of especial interest to those interested in the utilization of superpressure are announced. (1) A dead-weight gage (free piston type) with auxiliary apparatus for developing and measuring pressures up to 50,000 lbs./in.^{2} or more, for calibrating Bourdon gages, calibrating manganin and piezoelectric gages used in measuring gun breech pressures, and in general, the precise measurement of high pressures far be-

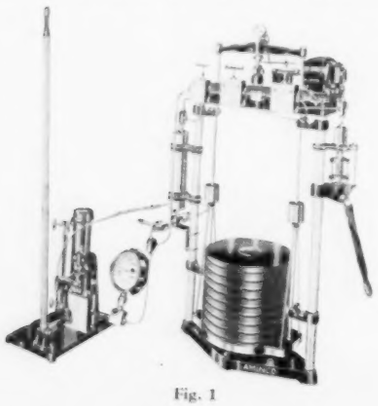


Fig. 1

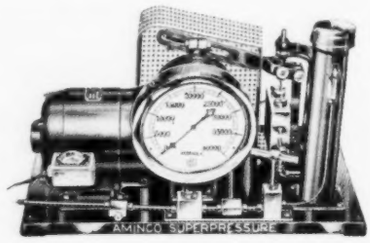
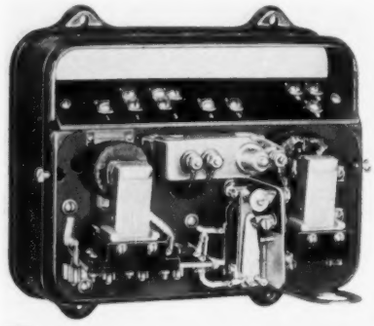


Fig. 2

yond the range of ordinary commercial equipment. Fig. 1 shows dead-weight gage with a two-stage pressure device consisting of a hand hydraulic pump capable of developing up to 15,000 lbs./in.^{2}, and a 10:1 ratio pressure intensifier. (2) A motor-driven pump, Fig. 2, for developing hydraulic pressures up to 30,000 lbs./in.^{2} (2000 atmospheres) for testing high-pressure containers, ordnance, etc.—*American Instrument Co., Silver Springs, Md.*

Burner Control

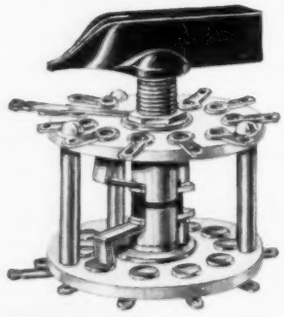
"Type R157A Protectorelay" industrial oil burner control permits predetermined ignition timing, delayed opening of the oil valve, if required, and timed scavenger or recycling period. It incorporates the basic "Series 10" circuit using one line-voltage and one low-voltage relay. One time switch is utilized for both ignition and oil valve as well as providing a timed delayed return to the cold position. New device is offered for use with "Type C56 Pyrostat" mounted in stack or breeching to provide safe operation of burner. This three-wire safety control overlaps on the heating cycle but not on the cool-



ing cycle. Ignition switch timing is adjustable from 45 to 120 seconds with a factory setting of 120 seconds. Delayed oil valve timing is approximately 25 to 35 seconds, and safety switch timing is approximately 80 to 100 seconds. Current rating is 10 amps. at 110 volts and 5 amps. at 220 volts with a motor rating of 1 h-p. repulsion-induction and ½ h-p. split-phase. Cabinet is approximately 7½" high and 7⅞" wide.—*Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

SHALLCROSS

Resistors, Switches and Instruments



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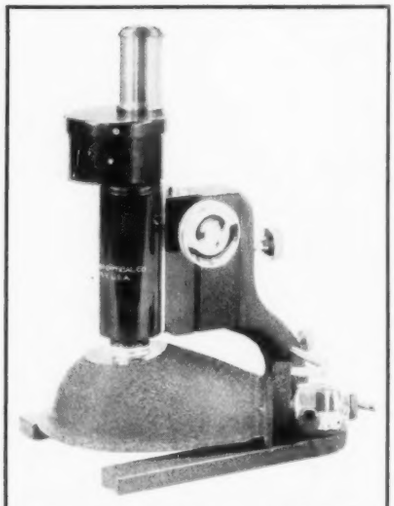

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Harry W. Dietert Co.

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Conductivity Bridge

For measuring resistances and electrolytic conductivity, two new models of a portable bridge are announced, operating from 110 to 400 volt and 25 to

60 cycle supplies; with or without dip cell and thermometer. Each model may be used to measure specific resistance of electrolytes from 0.2 ohm to 2 megohms, and resistances from 0.2 ohm to 0.25 megohm. Accuracy is ±2% except at extremities of calibration, is not affected by line voltage variations. Basic circuit is a-c. bridge with 3-volt input obtained from transformer, Type 6N5 cathode-ray balance indicator, preamplifier stage ahead of balance indicator and built-in d-c. power supply for amplifier and null indicator. Dial scale length is approx. 14"; multipliers provide five decade ranges so that with range switch at "1" the dial reads in single ohms. Walnut case with removable lid; dimensions 11"×8¼"×7⅛". — *Solar Mfg. Corp., 599 Broadway, New York City.*

"Combustrol"

Complete automatization of four essential protective functions has been realized in this combination of ignition, shut-off and time delay mechanisms, known as the "Combustrol." It safeguards ovens, furnaces, kilns, etc., against explosions by (1) following a pre-determined safe cycle in lighting the burners, as well as (2) completely shutting off fuel in case of pilot failure. One "Combustrol" can safeguard a multiple-burner installation without requiring complicated wiring. Red and green signal lights make status of operating circuit visible from a distance. Dependence on human judgment as to length of safe period is eliminated by a venting period of 10 min. (or other preset interval) during which no fuel is available. At end of this period, ignition transformer and pilot valve are energized, but there follows a one-minute period for automatically testing safe lighting of pilot. Then only does main valve open and do burners light. Control then remains in operating position until, in event of pilot failure, mechan-

ism instantly resets itself and both venting and pilot lighting periods must be repeated. Dimensions approx. 10"×6½"×5". Complete mechanism swings out of case for inspection.—*General Combustion Corp., 205 West Wacker Drive, Chicago, Ill.*

Three-inch Dial Thermometer

Back-stem 3"-dial bi-metallic type thermometer represents first industrial-instrument application of "Rotatherm Units" (*see Instruments*, Nov. 1935, page

305) the previously-announced embodiment (*see Instruments*, July 1937, page 177) being for the general public. "Coils-within-coils" element is not impaired by moderate over-ranging, is so sheathed in stinless-teel stem as to minimize lag while affording adequate mechanical protection. Entire assembly (see illustration) is such that thermometer is "practically unbreakable in use." Available in three ranges: (1) For dryers, 50-500°F; (2) for ovens, 150-750°F; (3) for ovens, 200-1000°F. Black graduations on "anodized aluminum" dial which is unaffected by temperature to which the head may be exposed. Accuracy guarantee 1% scale range.—*Weston Electrical Instrument Co., 591 Frelinghuysen Ave., Newark, N. J.*

Leitz

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BINOCULAR STEREO MICROSCOPES
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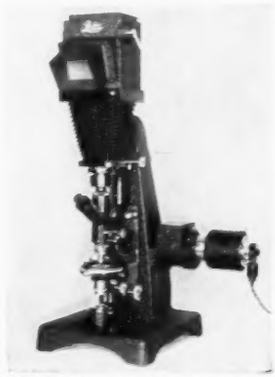

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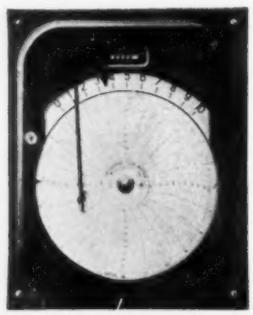

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OSCILLOGRAPH

This modern Cathode Ray Oscillograph incorporates many advanced features. It employs a Du Mont type 54-XH, 5 inch Cathode Ray Tube which provides a hair line trace, uniform focus over the entire screen, long life and high intensity. The features of two stages of amplification on the vertical, separate power supplies for the cathode ray tube and sweep circuit insuring no interaction of controls, a high gain sweep expanding amplifier which allows observation of waves of much higher frequency than the fundamental frequency of the sweep, are only a few of the features which make the type 168 an outstanding instrument.

For complete details write

Allen B. Du Mont Laboratories
INC.
Upper Montclair, New Jersey

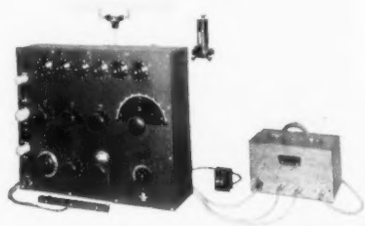
Megohm Bridge

Circuit of "Type 544-B" Megohm Bridge is that of a conventional Wheatstone bridge with a vacuum-tube voltmeter used as the detector. Bridge is balanced by means of a logarithmic dial and a multiplier switch. A microammeter in the plate circuit of the vacuum tube detector serves as a null indicator. Useful range of measurement is 0.1 megohm to 10,000 megohms, which is covered by an effective scale length of 35". Resistances up to one mega-megohm (10^{12} ohms) can be detected. Provision is made for the measurement of 3-terminal samples using guard electrodes. Voltage across sample is 90 volts, remains practically constant during balance. Terminals are provided for applying up to 500 volts to the bridge from an external source. Applications include measuring insulation resistance of cables and electrical machinery, leakage resistance of condensers, and volume resistivity of insulating materials. Since volume resistivity is sensitive to small traces of moisture, measurements with this bridge can be used as a measure of moisture content. Accuracy is ±3% between 0.1 megohm and 100 megohms, ±6% between 100 megohms and 10,000 megohms. Accuracies of better than 1% can be obtained by using an external decade-resistance box. Instrument is supplied for either a-c. or battery operation, weighs approx. 30 lbs., measures 22½" × 8½" × 8" overall.—*General Radio Co., 30 State St., Cambridge, Mass.*

Turn back to
Page A9

Modified Schering Bridge

For determining dielectric characteristics of samples of both liquid and solid insulating materials, this modified form of Schering bridge is said to combine convenience, safety and accuracy. High voltage is applied only to the test sample and to the standard air capacitor. All adjustable elements being confined within a grounded shield, operator is fully protected and accuracy is assured. Guard rings of standard capacitor and of sample are brought to proper potential by merely connecting them to the grounded shield. A method of compensation for residual capacitance is used which enables results to be calculated from simple equations. In the case of low power factors, result is read directly. Capacitances ranging from 40 μf to 0.020 mf and power factors from 0.0001 to 0.70 can be accurately determined. New bridge is intended for use on 60-cycle circuits; standard air capacitor and sample holders listed are rated at 10 kv. Apparatus for other voltages and frequencies can be supplied.—*Leeds & Northrup Co., 4955 Stenton Ave., Philadelphia, Penna.*



Tank Regulator

"Type M508 National Surface Tank Regulator" for coal- or coke-fired installations may be mounted on a vertical or horizontal line of pipe, or on the hot-water tank itself. Three "Metaphram" individual diaphragms, constructed of Admiralty brass (which is not heated or spun in the manufacturing process, thus retaining full resiliency of the brass) are incorporated to provide "greater sensitivity, more movement and more power." The regulator is regularly furnished complete with one 3-lb. weight, a 17¼" lever, damper chain, "S" hooks and straps for mounting purposes. It is available also with a section of pipe and damper.—*National Regulator Div., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*

Multiple-orifice Flowmeter for High Pressures

A multiple-orifice flow-meter of the U-tube type, suitable for measuring a wide range of flow-rates at pressures from 200 to 600 lbs./in.^{2}, is announced. All parts subjected to stress are said to be unusually strong, and the front of the instrument is protected by a heavy shatter-proof glass plate. By loosening the gaskets of the orifice plate, it may be revolved so as to use any of four different sizes of orifice, according to the quantity of fluid being measured. The complete unit is stated to consist of a high-pressure manometer, multiple orifice plate, connecting piping, bypass valve, and wrench and cleaning brush.—*The Meriam Company, 1955 West 112th St., Cleveland, Ohio.*

Stiffness Tester

For measuring stiffness of sheet materials such as paper, textiles, plastics, rubber, leather, etc. (and of wires, yarns, bristles, etc., by using special holders) this new "Saxl Stiffness Tester" establishes numerical values of rigidity, yield points, elastic recovery and other measurable properties, thus placing "stiffness" on a quantitative basis.—*R. Y. Ferner Co., 161 Devonshire St., Boston, Mass.*

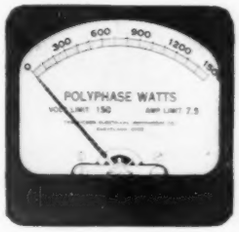
Direction-finder Loop

A simplified type of shielded loop, which can be rotated for direction-finding service in aviation, serves also to minimize disturbances in radio reception caused by rain, snow and sleet static. Primarily for use with "14" and "20" type receivers, equipment is applicable also to other types; slight modifications required

in a receiver to employ new device do not affect receiver's reliability or interchangeability. For taking radio bearings by the aural null-method, loop is rotated by a control unit having a 264-to-1 gear ratio and connected to the loop through a flexible shaft. Loop position is accurately indicated at control unit.—*Western Electric Co., 195 Broadway, New York City.*

Rectangular Instruments

A new line of miniature rectangular switchboard instruments comprises frequency meters, polyphase wattmeters, single-phase wattmeters, ammeters, voltmeters, etc. Mount is flush in round hole (3½" diam.). Instrument flange projects ½" in front of panel. A-c. instruments can be supplied with illuminated dials. Front of instrument has full open face for easily reading scale, which is over



3¾" long. Case and front are of heavy molded phenolic material, insulated in accordance with A.I.E.E. specifications. Shield can be supplied for the case where necessary to neutralize effect of external magnetic fields.—*The Hickok Electrical Instrument Co., Cleveland, Ohio.*

Tester Cabinets

"Laboratory Test Bench Panels" are announced in three cabinet styles, in which any Triplett "Master" or "DeLuxe" line tester may be installed. Cabi-

nets may be obtained complete with testers, or units can be added as required. Model 1403 (illustrated) accommodates one "DeLuxe" and two "Master" testers. Model 1402 has compartments for two "DeLuxe" instruments, and Model 1404 will hold any four "Master" units. Testers can be easily removed for field use. Any two or more cabinets may be bolted together to form a continuous panel. Cabinets are of black wrinkle finish metal, with front trimmed in red and white. Drawer at bottom for accessories. Height 22½"; width 16"; depth 7¾" at bottom and 5" at top.—*The Triplett Electrical Instrument Co., Bluffton, O.*

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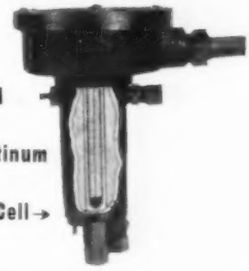

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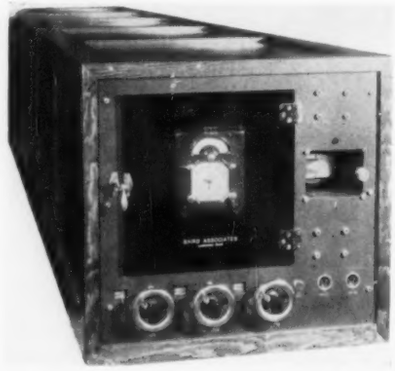
Specific purpose is testing the rotating standards which are used in turn for calibrating ordinary meters. Equipment consists of: (1) Master clock, wall type, with motor-wound weight-driven Graham dead-beat escapement movement. Invar seconds-beat pendulum can be regulated to maximum variation of 10 secs. per month. Seconds impulses are obtained photoelectrically. (2) Chassis mounted on top of master clock contains rectifier and amplifier tubes, capacitors, etc. (3) Bench control unit comprises impulse-operated mechanism, switches, etc., and has two dials: left-hand scale being 50 sec. and right-hand completing revolution in 4998 secs. (100 divisions × 50—the tripping interval), enabling use of convenient procedure. Equipment may be furnished to operate from a.c. or d.c. Materials and workmanship are such that timing accuracy guarantee is 0.008 sec. —*The Standard Electric Time Co., Springfield, Mass.*

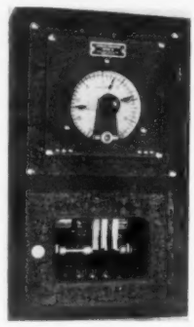
Spectrograph

Designed for industrial research laboratories, metallurgical companies and foundries (especially for routine spectrographic chemical analysis) and for colleges and universities desiring the flexibility of a grating instrument, this new concave grating spectrograph is built around a 3-meter, 15,000-line-to-the-inch, aluminum-surfaced diffraction grating. Mounting is modified Eagle type with all moving parts controlled from a panel which also contains slit assembly. Grating position, focus, and rack for positioning spectra on plate are set by revolution counters. A control is also provided on panel for superimposing spectra of different heights. Some features: (1) Dispersion 5 A.U./mm. in first order with grating concentrating approx. 80% of the incident light in that order; (2) Instrument will resolve Hg 5461 into its several components in the fourth order; (3) Spectral limit 1900 A.U. in first order ultra-violet; (4) Ghosts, in general, 1/500th of first-order spectra. Plate holder, taking 4″×10″ plates or smaller, is inserted through a light-tight door in front panel when rack is at zero, at which position dark-slide covers plate or film. As plate holder moves down for successive exposures, dark-slide remains fixed uncovering plate only as each successive spectrum is taken. An interval timing clock, in door on panel, is connected in a circuit with the shutter behind the slit and a small pilot light above the slit. Interval timer contains also a relay which may be connected to control the light source. Instrument is 120″ long, 22″ wide and 20″ high. Panel and optical system form one unit, insulated from light-tight case. Each instrument is set up in user's laboratory and there calibrated by supplier.—*Baird Associates, 20 Palmer St., Cambridge, Mass.*



Furnace Firing Reversal Timer

Designed to control, on a time basis, the firing of furnaces which are fired at each end, such as soaking pits and open hearths, this new timer differs from previous models having same purpose (see *Instruments*, July 1937, page 177) in that it has one dial having two pre-set pointers and one pointer which moves during timing operations. Each fixed pointer is controlled by a separate knob and is set for the desired firing time on one end of the furnace. In illustration, right pointer is shown set for 9 min. and left for 12 min. Maximum range in instrument shown is 20 min. This range can be changed to suit conditions. Total firing cycle of furnace is the sum of the two pointer readings—in this case 21 min. Cam unit can be arranged to operate each valve or damper directly if desired, and, for this purpose, can be equipped with any required number of load circuits.—*Automatic Temperature Control Co., 34 East Logan St., Philadelphia, Pa.*



Electric Valve

Designed especially for the control of water supply to air conditioners and humidifiers, but suitable also for the control of gas, oil, steam, and various liquids, new "Type H" solenoid valve embodies a novel scheme for attaching BX cable: lower half of coil housing is empty, and allows wires to be pushed into this space after connections are made with the coil leads. Then the BX sheath is held in place by the housing connector. Another feature is absence of usual click of plunger when valve opens or closes: plunger has a "composition tip" to close valve quietly and upper end of plunger travel is silenced by a rubber pad.—*Supreme Electric Products Corp., Rochester, N. Y.*

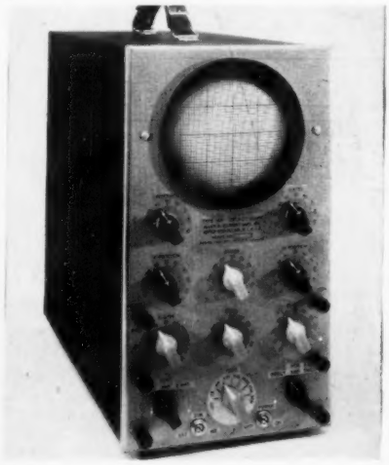
Bridge and Analyzer

Tobe Condenser Bridge and Analyzer for testing resistors, paper dielectric and electrolytic condensers, etc., between 1 ohm and 1 megohm, and 10 $\mu\mu$f and 100

μf, utilizes an "electronic eye" as a bridge balance indicator, with a preamplifier stage ahead of the indicator and a gain control in the preamplifier stage to allow adjustment of balance sensitivity. Another feature is linear graduation of main control dial (100 even divisions). Effective scale length (5 ranges) is 70". Range extension is effected by means of a decade multiplier switch. All controls are direct-reading. Equipment includes a built-in power supply for operation from 110-volt 60-cycle supply; tubes as follows: 6G6, 6C6, 01A, and special neon indicator tube.—*Tobe Deutschmann Corp., Canton, Mass.*

Five-inch Oscillograph

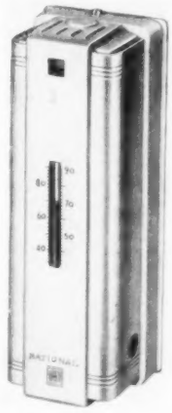
Said to incorporate "the best features evolved so far in this art," "Type 168" portable cathode-ray oscillograph employs a 5-inch sharp-focus tube with



high-intensity fluorescent screen which, together with adequate amplification, permits of daylight observation as well as photographing. A switch permits the vertical plates to be used direct or with one stage of amplification or with two stages. High input impedance for horizontal and vertical plates does not disturb the majority of circuits usually investigated. Gain with single stage is 70, and 450 with two stages. Horizontal amplifier, a single stage used either for external signal or to amplify the internal linear sweep, has a gain of 50. There is no undesirable interaction between vertical and horizontal amplifier circuits. Sweep circuit has a frequency range from 15 to 30,000 cycles. By means of a new sweep-expanding amplifier for complex wave studies, sweep may be spread sufficiently to observe waves up to one megacycle. Pattern size may be altered without upsetting in any way the frequencies involved. The usual return trace is eliminated by employment of a television-apparatus principle. Positioning controls center the pattern. A removable calibrated scale permits accurate determinations. The instrument operates on the usual 115-volt 60-cycle supply. It draws 50 watts.—*Allen B. DuMont Laboratories, Inc., Upper Montclair, N. J.*

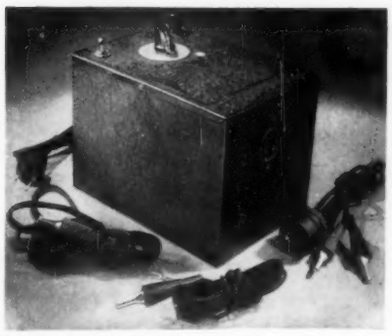
Thermostats

"National Helmet Sealed" thermostats have been redesigned along the lines of other Minneapolis-Honeywell thermostats. This also affects the "National" line of room type humidity controllers. All moving parts operate in a sealed chamber, excluding dirt, chemicals, chalk dust, etc. and preventing disturbing mechanism by pushing a pencil or other object through openings in case. National's thermostatic element of "Ebonite" has been retained. Overall size has been greatly reduced, but adjustment features of previous model remain. The thermometer has been recessed for protection. Temperature range has been changed from 35-82° F. to 46-90° F.—*National Regulator Div., Minneapolis-Honeywell Regulator Co., Minneapolis, Minn.*



Line Noise Analyzer

"Aerovox Line Noise Analyzer" comprises various forms of filters thrown into circuit by a selector switch, together with attachment cords, plugs and con-



nectors. Different filter arrangements are tried out by rotating the selector switch; also various connections and grounds. When noise is reduced to minimum, analyzer indicates the standard type filter to use in duplicating the same setup. Cords, plugs and connectors fit into a compartment when not in use. —*Aerovox Corp., 70 Washington St., Brooklyn, N. Y.*

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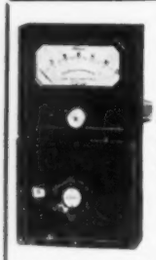

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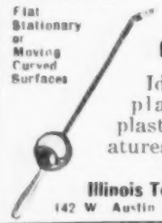

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Sound Apparatus

A new line of P-A and sound reenforcement equipment includes among other technical developments: (1) A remote electric mixer (Fig. 1) with which

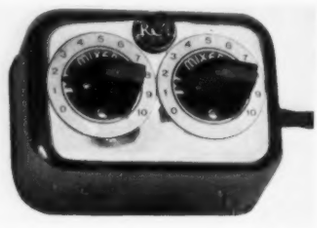


Fig. 1

the operator may control volume from a strategic position in an auditorium or other gathering place instead of at the amplifier behind the scenes where inputs frequently are mixed by sheer guesswork. Unit measures $3\frac{1}{8}'' \times 4\frac{1}{2}'' \times 2\frac{1}{2}''$ and weighs 2 lbs., has two controls or more as specified. (2) P-A system PG-111 especially suited for small auditoriums, bus terminals, etc., has a frequency response of 90 to 10,000 cycles, ± 2 db, weighs 25 lbs. (3) PG-112 is a 12-watt portable sound system for audiences up to 2000 persons. Its amplifier can operate either from a 110-volt a-c. source or from a 6-volt storage battery in conjunction with a dynamotor, makes the system suitable for mobile applications. (4) New 6-watt amplifier is a compact unit especially adapted for paging systems, call service, etc., measures about $10'' \times 8'' \times 7''$, weighs 8 lbs., has a flat frequency response of 90 to 10,000 cycles, within ± 2 db, overall gain of 110 db and utilizes a 6L6 beam power output tube. (5) In new 12-watt amplifier, electronic mixing of a new type permits different inputs to be mixed in one tube without modulation distortion. Other features are 112-db beam power tubes for high output at low distortion, tone control and phonograph jack; and both low and high

Fig. 2

impedance inputs, each separately controlled. All controls are handily placed on a sloping control board. Operable from storage battery and dynamotor, or 110-volt a-c. Dimensions $14\frac{1}{8}'' \times 8\frac{1}{8}'' \times 8''$. (6) New 24-watt amplifier (Fig. 2) is said to incorporate advanced circuit design and to be extremely flexible in operation. With it, RCA's new remote electric mixing unit (1) may be used. It utilizes metal tubes in all stages, beam power output tubes, with reverse feedback circuit, automatic bass compensation, shielded input transformers for each cushion-mounted pre-amplifier, input mixing facilities for two or four positions, speech-music switch, continuously variable tone control and a pilot lamp. There are two microphone preamplifiers with microphone input jacks. (7) Finally, a new 50-watt Class "A" amplifier (Fig. 3) with built-in expander and suppressor circuits to enhance musical reproduction and prevent blasting and overloading in large-scale P-A and sound re-enforcement installations. It consists of two units: A voltage amplifier (foreground of Fig. 3) which is of the high-gain type, incorporates newly designed high-level mixing circuits, can drive from one to eight power amplifiers and—since it uses metal tubes—can be operated by the Fig. 1 remote electric mixer. Space is provided for adding two signal mixing units in addition to the two included in the specifications. Low frequencies can be cut out for compensating between speech and music pickup. Suppressor circuits hold volume constant as long as the speaker stays in near vicinity of the microphone. The power amplifier (background, Fig. 3) utilizes four beam power tubes—all operated at conservative ratings—for obtaining high-

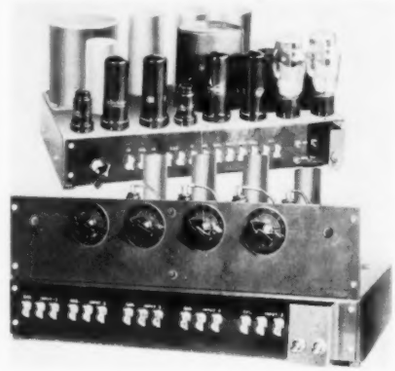
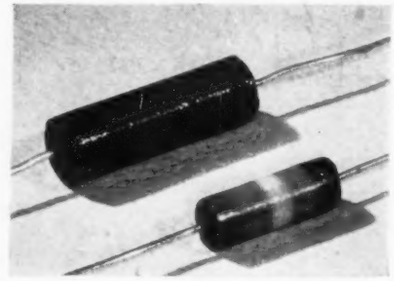


Fig. 3

power low-distortion output. A high-frequency tone control gives up to 24 db cut at 10,000 cycles, while degenerative circuits have been applied to the driver to provide low distortion and effective loudspeaker dampening to the extent that the output may be varied from full-load to a single loudspeaker with only a 20% rise in output voltage.—*RCA Mfg. Co., Camden, N. J.*

Carbon Resistors

Carbon resistors in Bakelite molded jackets with color-coding lacquer stripes and 2″ pigtail leads of tinned copper, are available in $\frac{1}{2}$-watt and 1-watt ratings, in resistance values from 100 ohms to 10 megohms. Tolerance $\pm$ 10% for standard units, closer on special order. —*Aerovox Corp., 70 Washington St., Brooklyn, N. Y.*



A Wide-range Vacuum-tube Resistance Bridge

By IDRIS I. DAVIES

Forest Products Laboratory,[1] Forest Service, U. S. Department of Agriculture

IN order to measure conveniently and accurately the electrical resistance of chemically seasoned wood[2] the Forest Products Laboratory designed and developed the portable instrument described here. In addition to its use in measuring the electrical resistance of wood and other hygroscopic materials, the instrument can be used to measure leakage resistance in cables and other electrical equipment.

GENERAL DESCRIPTION OF CIRCUIT

The instrument comprises a Wheatstone bridge circuit of the slide-wire variety combined with a vacuum-tube system for detection of bridge balance. The circuit also includes an a-c.-operated power supply system. The instrument possesses sufficient sensitivity to make possible resistance measurements over a range extending from less than 100 ohms to more than 200,000 megohms.

Fig. 1 shows the complete circuit which may be broken down into the following three minor circuits:

(1) The bridge circuit, composed of a high-resistance slide wire R_1, any of the standard resistances RS_1 to RS_7, inclusive, and the resistance of unknown value being measured, R_x. The portions of the slide wire R_1 on either side of the sliding contact point, C, form two arms of this bridge. Any one of the standard resistances, RS_1 to RS_7, inclusive, which may be switched into the circuit by means of the standard resistance selector switch, form the third arm, and the unknown resistance being measured, R_x forms the remaining arm.

(2) The bridge-balance indicating circuit consisting of a double-triode vacuum tube $V.T.$, an adjustable tapped resistance R_2, a 1-0-1 milliammeter M, a grid-biasing resistance R_5, and a grid bias adjusting potentiometer R_4.

(3) The power supply system—a duplicate of the systems used in many a-c. radio receivers—consists of a power transformer, full-wave vacuum-tube rectifier, filter choke, filter condenser, and voltage divider R_3. This power supply system provides the necessary direct currents at the proper voltages for operation of the bridge and bridge-balance indicating circuits and supplies a low voltage alternating current for heating the cathodes of the vacuum tube $V.T.$ and for lighting the selective dial lamps.

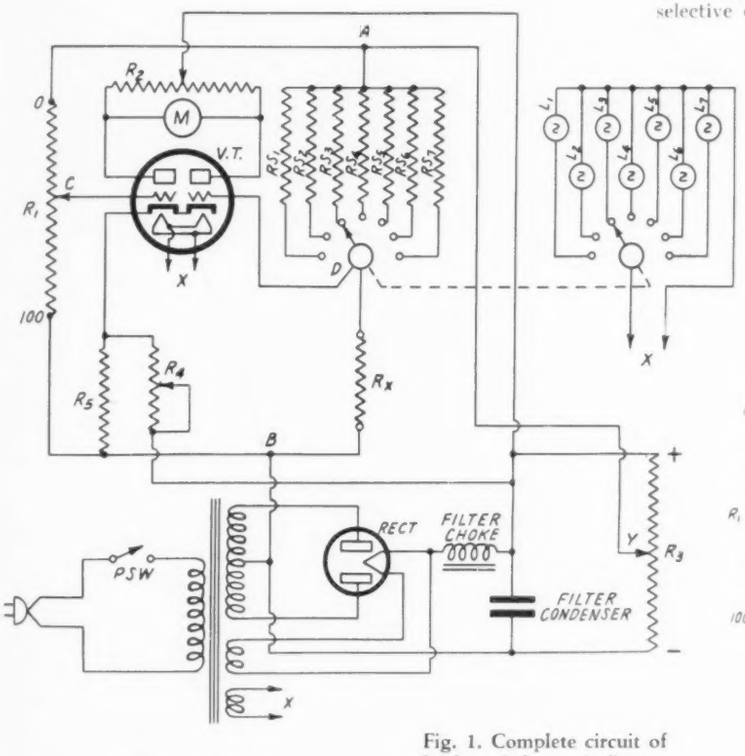


Fig. 1. Complete circuit of bridge, balance indicator, and power supply system.

CIRCUIT OPERATION

The bridge-balance indicator circuit (Fig. 2) is in itself a bridge circuit. Two arms of the bridge are formed by the portions of resistance R_2 on either side of its adjustable point. The other two arms are formed by the plate-to-cathode resistance of the two halves of the double triode vacuum tube. These plate-to-cathode resistances are represented by RP_1 and RP_2.

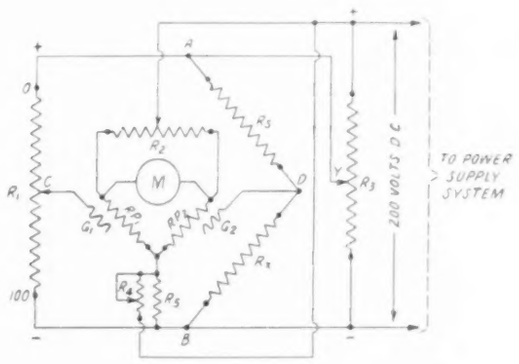


Fig. 2. Bridge and balance indicator circuit.

The milliammeter M is connected in the usual position in this bridge circuit. Insofar as the action of the vacuum tube is concerned in this circuit, RP_1 and RP_2 are two variable resistances the values of which are under control of the negative charge on their associated grids.

When the grids G_1 and G_2 are held at the same voltage and equal voltages are applied to the plates of the vacuum tube $V.T.$, RP_1 and RP_2 will have the same value. If, with RP_1 and RP_2 of like value, the adjustable point on R_2 be moved to a position where the resistance of R_2 on either side of this point is equal, the bridge which forms the balance indicating circuit will be in balance

[1] Maintained at Madison, Wis., in coöperation with the University of Wisconsin.

[2] The seasoning of wood with chemicals, which has recently been developed at the Forest Products Laboratory, not only shortens the seasoning process and reduces drying degrade but also modifies the electrical resistance of wood. Some chemicals modify the electrical resistance markedly whereas others have practically no effect. For some uses of wood, such as electric transmission poles and cross arms, the degree to which the electrical resistance of wood is modified by the chemicals remaining in the wood may prove the determining factor in the selection of the chemical for the seasoning treatment.

and the milliammeter M will show no deflection. Slight differences in the electrical characteristics of the two halves of the vacuum tube can be compensated for by moving the adjustable contact on R_2 to a position where the milliammeter shows no deflection when both grids are given the same negative potential. It is necessary to make this adjustment only when a new vacuum tube is placed in service.

The bridge-balance indicating circuit is connected to the power supply circuit at the adjustable point on R_2 and at the lower end of R_5. The full voltage of the power supply system is applied across the balance-indicating circuit at these points and the total amount of current flowing in the plate circuits of the vacuum tube is returned to the negative side of the circuit through resistance R_5. This flow of current through R_5 results in a voltage drop across R_5 and gives the cathodes of the vacuum tube to which it is connected a positive value with respect to the negative side of the circuit.

Grids G_1 and G_2 are connected to the main bridge circuit at points C and D. When the main bridge is in balance the voltage at these points will be equal, therefore the voltage of the two grids will be equal and the milliammeter will show no deflection.

In order to measure resistances having extremely high values, no current must flow from the grids to the cathodes of the vacuum tube. By maintaining the grids at the proper negative potential at all points of balance representing all settings of point C on the slide wire R_1 a flow of grid current is prevented. The grids are given a negative bias by holding their voltage at a value less positive than the value of the voltage drop across resistance R_5. The grids and the cathodes are positive with respect to the negative side of the circuit but because the positive voltage at the cathodes is higher than the positive voltage at the grids, the grids are negative with respect to the cathodes by the difference between the values of these voltages.

If the grid bias voltage is once set at the proper value it will not vary by more than a negligible amount for any setting of point C on R_1 when the bridge circuit is balanced. The value of the negative bias on Grids G_1 and G_2 for any bridge balance point on the arbitrary scale of R_1 is shown in Fig. 3. Curve A represents the voltage between the cathodes and the negative side of the circuit or the voltage drop across R_5 for any balanced position of point C on R_1. Curve B represents the voltage difference between point C and the negative side of the circuit for any balanced position of point C on R_1. When a condition of bridge balance exists, the voltage between point D and the negative side of the circuit will be equal to the voltage between point C and the negative side of the circuit, therefore curve B applies to both grids G_1 and G_2. Curve C, which represents the value of the negative bias on both grids, is equal to the difference between curve A and curve B at any balance point on the arbitrary scale of R_1.

The adjustable high resistance R_4 serves as a manual adjustment for raising or lowering the value of the bias voltage on the grids of the vacuum tube. This adjustment permits changes to be made in the sensitivity of the balance indicating circuit. It can be seen that R_4 is connected between the positive side of the power supply system and the cathodes of the vacuum tube at their point of connection with R_5. In addition to the plate currents which return to the negative side of the circuit through R_5, a small amount of current is drawn directly from the positive side of the power supply system and flows to the negative side of the circuit through R_4 and R_5 in series. This additional current increases the voltage drop across R_5 and permits the negative bias on the grids of the vacuum tube to be of the proper value without R_5 having a large resistance value.

By adjusting R_4 to a lower resistance value the voltage drop across R_5 can be raised, thus increasing the bias voltage on grids G_1 and G_2 and decreasing the sensitivity of the balance indicating circuit. If R_5 be decreased to its minimum value, the negative grid bias would be raised to the "cut-off" point and the circuit would be inoperative. With R_5 adjusted to its maximum value the negative grid bias will be at its minimum value and the circuit will be in its most sensitive operating condition.

The vacuum-tube bridge-balance indicator described here, unlike most bridge-balance indicating systems, automatically increases its sensitivity as the balance or null point is approached. Moreover, when conditions of extreme unbalance exist, only a predetermined maximum deflection of the milliammeter can take place.

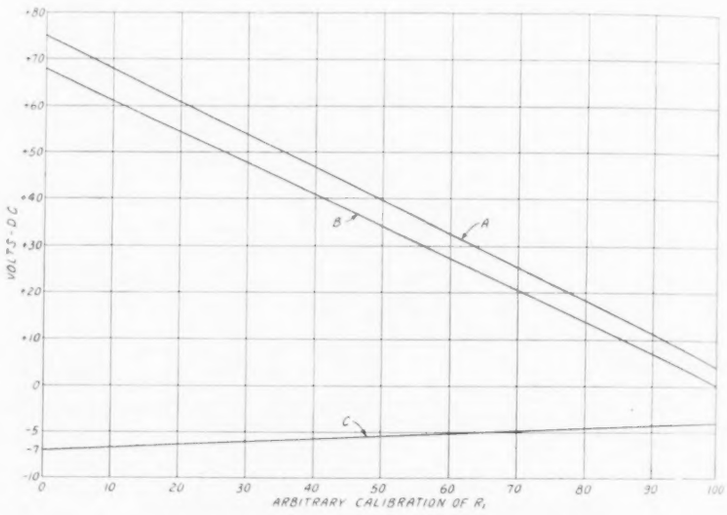


Fig. 3. Curves showing relationship of cathode and grid voltages to negative grid bias.

To explain the manner in which the balance-indicating circuit automatically increases its sensitivity as the null point is approached and decreases its sensitivity as the degree of unbalance is increased, it is assumed that the circuit is in a balanced condition. In this condition the positive voltage of both grids with respect to the negative side of the circuit are equal and the grids are negatively biased with respect to their associated cathodes by the same amount. The plate currents in both plate circuits are equal and there is no flow of current through the milliammeter M. If the bridge is intentionally unbalanced by moving point C on R_1 toward the 0 end of its arbitrary scale the following current and voltage changes take place in the circuit. The voltage at point C and the voltage at G_1 will become more positive with respect to the negative side of the circuit and less negative with respect to its associated cathode, meaning a decrease in the negative bias on G_1. The plate current in the plate circuit, which is under control of G_1, will increase as a result of the decrease in negative bias. The increase in plate current in the plate circuit, which is under control of G_1, will increase the current flow through R_5 and increase the voltage drop across R_5. Owing to the increase in voltage drop across R_5 the negative bias on G_2 will be raised, since the positive value of G_2 has not been changed by this slight unbalance of

the bridge circuit. Grid G_2 will become more negative with respect to its associated cathode because of the increase of the positive value of the cathode with respect to the negative side of the circuit. The plate current in the plate circuit, which is under control of G_2, will decrease because of the increase in negative bias on G_2. The bridge formed by the two plate circuits of the vacuum tube and the portions of R_2 on either side of its adjustable point is now unbalanced and a difference in potential exists on either side of it at the points to which the milliammeter M is connected. The milliammeter M will show a deflection, indicating that the outer bridge circuit is unbalanced.

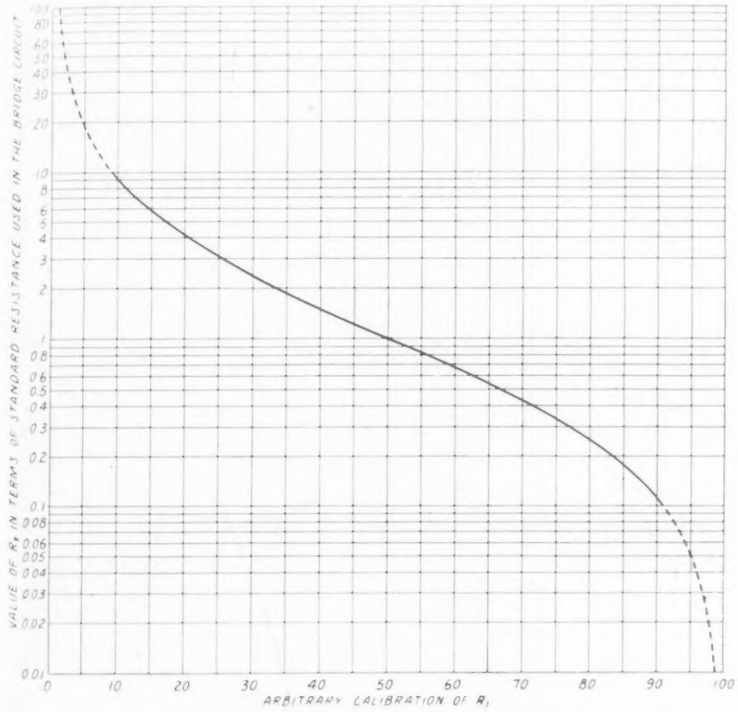


Fig. 4. Curve used in calibrating the slide-wire dial.

If the unbalancing of the bridge is continued in the same direction, it may be seen that the value of the negative bias of G_2 will increase until the cut-off point is reached, and no current will flow in its associated plate circuit. G_1 will become less negative with respect to its cathode until it has a positive bias permitting maximum plate current, limited in value by R_2, to flow in its associated plate circuit. Any further unbalancing of the bridge circuit will not increase the deflection of milliammeter M, because maximum current is already flowing in the plate circuit associated with G_1 and no current is flowing in the plate circuit associated with G_2.

If the condition of unbalance in the bridge circuit is brought about by moving point C away from its balance point, in a direction toward the negative end of R_1, the action as just described will occur in the reverse order and the milliammeter will deflect in the opposite direction.

From the foregoing explanation it may be seen that the circuit has its maximum sensitivity at the balance point of the bridge circuit to which it is connected. Owing to its decrease in sensitivity with an increase in the degree of bridge unbalance, it is not possible to damage the balance indicator even though the bridge to which it is connected is adjusted to the point of maximum unbalance.

The sensitivity of the vacuum-tube bridge-balance indicator does not decrease when the values of the standard resistance and the unknown resistance used in the bridge circuit are increased. This is because the circuit is voltage-operated and does not require a flow of current between its points of connection with the bridge circuit. The voltages measured between these points and the negative side of the circuit are independent of the value of the standard and unknown resistances, provided that no current is permitted to flow away from these points.

CALIBRATION OF THE HIGH RESISTANCE SLIDE WIRE DIAL

To enable direct readings to be made of the value of the resistance being measured, the dial of the high-resistance slide wire was provided with a separate calibrated scale for each of the standard resistances contained in the instrument. To avoid the necessity of having to calculate the value of the unknown resistance represented by each of the points on the arbitrary scale in combination with each of the standard resistances, the calibration curve shown in Fig. 4 was drawn.

The horizontal scale of Fig. 4 represents the arbitrary calibration of the slide-wire dial and the vertical scale is a scale of multipliers. The value of the unknown resistance, for any setting of the slide-wire dial, is equal to the product of the standard resistance used in the bridge circuit and the multiplier corresponding to the slide-wire dial setting, on the arbitrary scale.

It may be seen that the calibration curve tapers off quite rapidly near its ends, tending to produce a crowded condition of the calibration points. This condition can be corrected to a large extent by using a slide wire with the proper resistance taper near its ends, or one that shows a constant decrease in resistance per unit length from its mid-point toward its ends.

SPECIAL CONSIDERATIONS

By selecting the proper material for mounting and insulating the various parts which make up the instrument, circuit leakage can be reduced to a value which is negligible at all places in the circuit except one. This place is within the vacuum tube itself, where leakage takes place between the cathodes and the grids. This cathode to grid leakage, in effect, acts as a shunt resistance in series with R_2 around the unknown resistance R_x (Fig. 1).

For any one vacuum tube, the value of the above mentioned shunt resistance will be constant when the vacuum tube has attained a constant temperature and it can be treated as an external shunt resistance of constant value when the scale associated with the high standard resistance is calibrated.

The slight leakage that takes place within the vacuum tube does not introduce an appreciable error when a standard resistance of 100 megohms or lower is used but when a standard resistance of 100,000 megohms is used the effect of this leakage is to reduce the maximum high-resistance measuring range of the instrument to approximately 225,000 megohms.

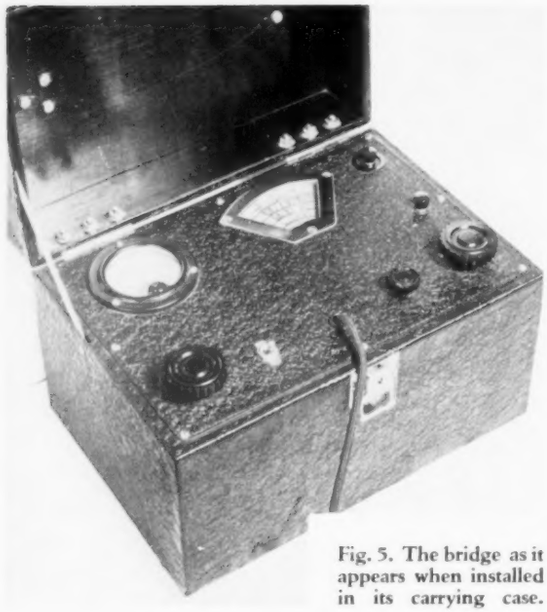


Fig. 5. The bridge as it appears when installed in its carrying case.

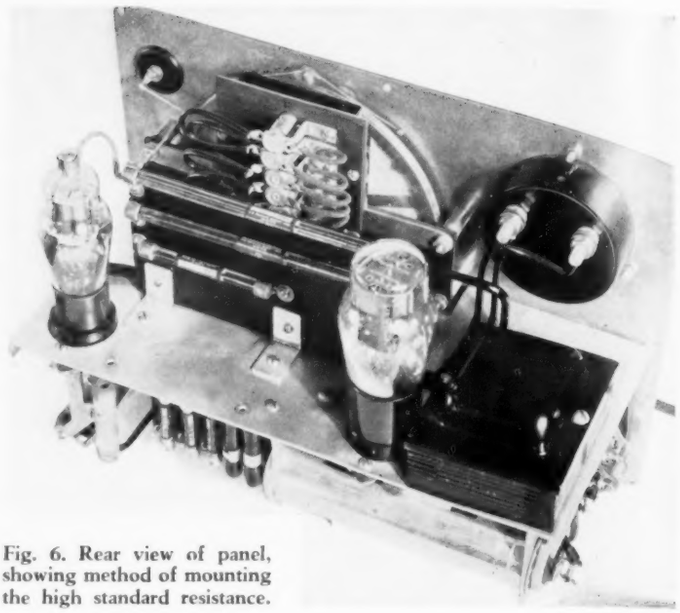


Fig. 6. Rear view of panel, showing method of mounting the high standard resistance.

A slight change in the design of the vacuum tube with respect to the method of mounting the various elements would greatly decrease the effect of this leakage and bring about a corresponding increase in the high resistance measuring range.

OPERATION

The completed instrument, designed for 110 volt a-c. operation and installed in a metal carrying case for the purpose of shielding, is shown in Fig. 5. It weighs less than twenty pounds.

The various knobs and other parts located on the panel serve the following purposes:

The large knob in the lower left corner operates the standard-resistance selector switch and is used to change the resistance-measuring range of the instrument. The other large knob in the lower right corner operates the calibrated high-resistance slide wire, the dial of which may be seen behind the window in the upper right corner. This dial carries a separate calibrated scale for each of the standard resistances. When any one of the standard resistances is switched into the bridge circuit a small dial lamp located behind the proper scale is lighted.

Each calibrated scale has its own dial lamp which is lighted only when that standard resistance with which the calibrated scale is associated, is switched into the bridge circuit. This system serves the purpose of illuminating the various scales and eliminates errors which would result from reading the wrong scale.

The small knob, seen to the left of the large knob used to operate the slide-wire dial, is used to make small adjustments in the value of the grid bias of the vacuum tube in the bridge-balance indicator circuit. The a-c. power switch and power cord are located at the forward side of the panel. The milliammeter in the upper left corner indicates when the bridge is brought to balance. The binding posts by which the resistance to be measured is connected into the bridge circuit are located to the right of the slide-wire dial window. Fig. 6 shows the manner in which the high standard resistance is mounted, as well as the locations of various other parts.

To make a resistance measurement the power cord should be connected to a 110-volt 60-cycle a-c. supply system. The power switch should be moved to the "on" position and approximately 1 minute allowed for the cathode of the vacuum tube in the bridge-balance indicating circuit to come up to temperature. The resistance of unknown value should not be connected to the instrument until after the slide-wire dial has been turned all the way to its high-resistance end. With the dial in this position, the pointer of the milliammeter should rest on 0 in the center of its scale, indicating that the circuit is properly adjusted for operation. If the milliammeter shows a deflection, the small knob for adjusting the grid bias must be turned to a position which causes the milliammeter to return to zero deflection. The circuit is now ready for use and the resistance to be measured may be connected to the terminals provided for that purpose.

When the unknown resistance is connected into the circuit, the milliammeter will deflect away from its zero position. The circuit is brought to balance by turning the slide-wire dial until the milliammeter again comes to rest at zero. The value of the unknown resistance can now be read directly from the dial: the correct scale to read being the only one illuminated.

CONCLUSION

Developed at the Forest Products Laboratory in connection with researches on the chemical seasoning of wood, the instrument has proved successful in measuring the electrical resistance of wood and other hygroscopic materials with a degree of rapidity and accuracy not common to most moisture meters. The instrument no doubt can also be used successfully to measure leakage resistance in cables and other electrical equipment.

The vacuum-tube bridge-balance indicator incorporated in the circuit can with slight modifications be used as a vacuum-tube voltmeter, capable of measuring an unusually wide range of voltages without drawing current from the voltage source.

The instrument is not in commercial production. A patent covering the complete instrument and its use as a resistance bridge and moisture meter has been applied for and is now pending action by the Patent Office. Should the patent be granted it will be dedicated to the free use of the people of the United States since the instrument has been developed in a Federal research laboratory.

Recent Scratch Hardness Methods

Tenth instalment of "Hardness and Hardness Measurements." See page 1, Jan. 1937 issue.

By S. R. WILLIAMS
Professor of Physics, Amherst College

EFFECT OF SURFACE CONDITION

Another factor which entered to give variation to the numbers (loads) obtained for hardness on the various minerals was the degree of polish of the surface. A smooth surface on a polished section could be scratched more easily than a not-so-smooth surface of the same mineral. This was particularly noticeable in the case of pyrite. Schneiderhohn[8] has suggested that this is possibly due to the development of an amorphous slip-film or smeared coating, due to the process of polishing, and which may wholly or in part conceal the property of the underlying structure. One would naturally wonder whether these scratched measurements on polished surfaces were due to the hardness of the slip-film or to that of the mineral.

Talmage checked on this point and came to the conclusion that the ease of scratching is to some extent a function of the smoothness of the surface. Schneiderhohn was of the opinion that the slip-film did not produce any effects on the hardness number. Both of these men worked with minerals, which still leaves open the question of the surface film produced on metals by polishing. We do know that the polished surface of a metal can set up enormous stresses. May not these affect hardness testing?

Out of the foregoing discussion emerges an old question as to whether the scratch method is an abrasion method or a moving indentation process. In the scratch process, as described, are portions of the test substance torn (abraded) from the body by the diamond edge or is the track left by the diamond edge wholly dependent upon the plastic flow of the test piece? Hankins[9] is of the opinion that in the older methods, abrasion was the chief result of a scratch test, but with the advent of properly designed diamond edges, a track of the edge over the surface of the body could be thought of as a permanent deformation in which the distortion is produced by flow under pressure and no particles of the test material are torn away.

RELATIONS BETWEEN DIFFERENT METHODS

Some years ago Stanton[10] defined an abrasion test as "a test in which the particles of the material whose hardness is to be determined are torn away from its surface by sliding contact with some other substance whose corresponding resistance is so high that its surface remains unimpaired by the action." It is in this sense of the word abrasion that the trace of a diamond edge may be left on a brittle body. If one draws the edge of a knife along the surface of a mass of moist clay the trace left is decidedly one of plastic flow.

From tests on a large variety of steels Hadfield and Main[11] showed that an empirical relation existed between Brinell numbers and scratch widths, namely, that if the Brinell number did not exceed 600, the number was approximately proportional to the inverse cube of the scratch width. Hankins more or less confirmed this and established the following equation:

$$\text{Scratch Hardness} = \frac{\text{Load on diamond} - p}{(\text{Width of scratch})^2 - q}$$

where p and q are small constants depending on the shape of the diamond. If p and q are neglected, the above equation takes on the form of a stress and since the Brinell number also has the dimensions of a stress, the inverse cubic relation between the Brinell number and the scratch width makes it appear that the same properties of a material are not being measured by the two methods.

Hankins further suggests that inasmuch as the Brinell number is obtained from the spherical area of the ball indentation, a better comparison of the scratch and ball tests could be made by plotting scratch width directly against diameters of the ball impressions. Fig. 55 shows such relationships as worked out by Hankins and supports the contention that the scratch tests are merely particular applications of the indentation tests. Hankins believes that the deviations shown in Fig. 55 for hard substances are due to definite changes in the general character of the ball test when flattening of the ball occurs.

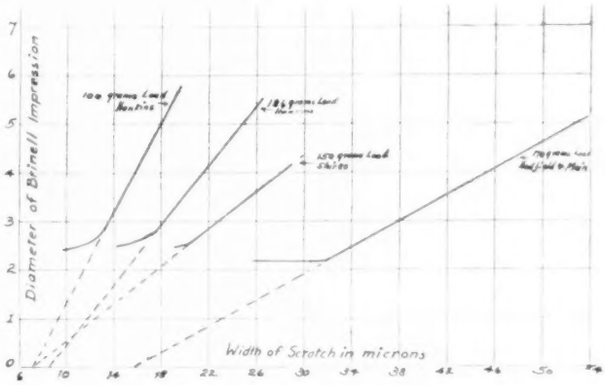


Fig. 55. Comparison of Brinell impression diameter with scratch width.

OTHER SCLEROMETERS

O'Neill[12] has developed a sclerometer in which the diamond edge has been replaced by a 1-mm. steel ball. This instrument was devised for the express purpose of studying directional hardness in single metallic crystals. For this purpose it seems to have worked satisfactorily as well as in testing the hardness of thin electro-deposits which are not above 400 Brinell. Still more serviceable

[8] H. Schneiderhohn. Anleitung zur Mikroskopischen Bestimmung und Untersuchung von Erzen, 1922, pages 59, 65, 111 and 118.

[9] G. A. Hankin. A Synopsis of the Present State of Knowledge of the Hardness and Abrasion Testing of Metals with Special Reference to the Work done during the Period, 1917-1927, and a Bibliography. *Proceedings Institution of Mechanical Engineers*, Vol. 1, May 1929, pages 317-373. Discussion, pages 374-387. See also *Engineering*, April 27, 1923, pages 537-540.

[10] (T. E. Stanton and R. G. Batson.) Hardness Tests Research. In Report of Hardness Tests Research Committee. *Proceedings Institution of Mechanical Engineers*, 1916, pages 678-723.

[11] R. A. Hadfield & S. A. Main. Note on Brinell and Scratch Tests for Hardened Steel. *Proceedings Institution of Mechanical Engineers*, Vol. 2, 1919, pages 581-586.

[12] H. O'Neill. The Ball Sklerometer. The Hardness of Metals and its Measurement. Chapman and Hall, London, 1934, pages 146-149.

Fig. 56. The O'Neill scratch instrument in which a small steel ball is used for the point.

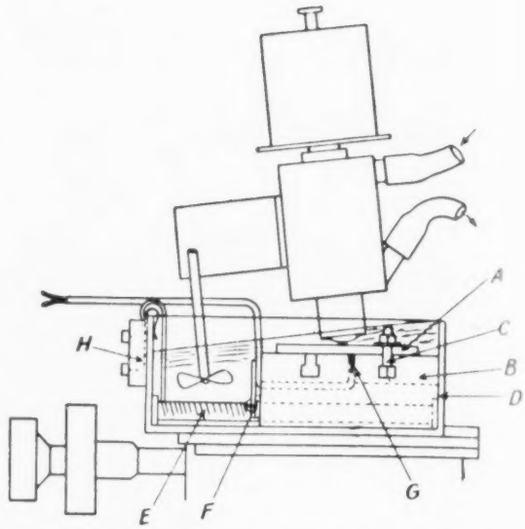


Fig. 57. O'Neill's sclerometer used in testing hardness under different degrees of temperature.

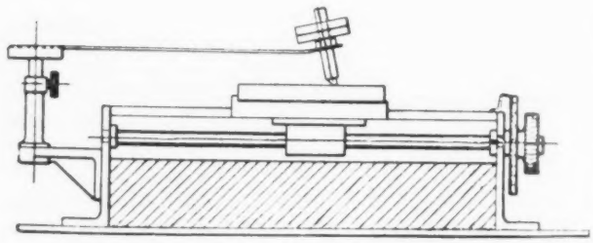


Fig. 58. Hankin's sclerometer.

was a diamond ball, 0.5 mm. in diameter, as the scratching point. Fig. 56 shows the finished instrument. "The sclerometer consists of a frame upon which is fixed a robust graduated mechanical stage inclined at 7° to the horizontal. The specimen is secured to the stage by clamps or wedges." O'Neill, in the description of his apparatus, shows some ball scratches passing the boundary between two crystals and under the magnification given (×160) they appear to give a clean cut edge to the trace. Fig. 57 shows an application of O'Neill's machine to the measurement of hardness of materials at higher than ordinary temperatures. As shown, the specimen is in a bath of paraffin at 200° C. O'Neill's instrument is of interest because it combines the scratch and indentation methods—the dynamic and static tests. The main difference arises from the fact that equilibrium is not attained during the translatory motion of the moving ball.

Hankins[13] has also devised a sclerometer which is shown in Fig. 58. In this instrument he used special shaped diamond points in which the values of p and q in his equation given above could be varied. He has found it of use in measuring the hardness of thin electro-deposits, but its sensitiveness to the effect of cold work in metals is unknown. There is so much similarity among many of these sclerometers that one ought to work with all of them before being able to make comparisons. For instance, compare this instrument with the one devised by Parsons.[14] Through correspondence and through conversations, the author has heard repeatedly that the scratch method is not applicable to testing the varying degrees of hardness developed by cold working. This seems to be a point of considerable interest. Why will not the scratch method work on hardness developed by cold working? The author has felt for some time that the scratch method needs considerable investigation before one can say how valuable the method is for general purposes. It may work quite satisfactorily in minerals, and another form of sclerometer may work advantageously on metals.

As a general problem the author has under way a comparison of two sclerometers, one in which the load is measured which gives a constant scratch width and another in which the width of scratch is a measure of hardness under the condition of a constant load. These two instruments are being tested on substances, to start with, which are neither minerals nor metals and the work may then be extended to both of these classes of materials. The investigation will be continued in a study of the minutiae of the traces left by the diamond edge in all classes of matter to see whether abrasion or plastic flow has occurred. The hardness of cold worked material will also be studied by means of these two methods because hardness by cold working, as the author has found, does not appear measurable by magnetic methods. A comparison will be made of the speed with which these two types of instruments can be used. Short,[15] in referring to Talmage's sclerometer says that his experience with the instrument indicated that it required about 15 minutes to make a reliable hardness test. Such an instrument could hardly be used in quantity production inspection.

Undoubtedly there are conditions where the scratch method is practically the only one available. As an example may be cited the variation in hardness as one crosses the boundary from one small crystal to another in a polycrystalline structure. The two instruments which have been selected for this study are the instrument shown in Fig. 51 and the microcharacter devised by Bierbaum[16] which will be discussed with considerable detail in the next section.

(To be continued)

[13] G. A. Hankins. Relation between Width of Scratch and Load on Diamond in the Scratch Hardness Test. *Proceedings Institution of Mechanical Engineers*, 1923, pages 423-449. Discussion, pages 449-487.

[14] A. L. Parsons. A New Sclerometer. *American Journal of Science*, Vol. 179, 1910, pages 162-168.

[15] M. N. Short. Microscopic Determination of the Ore Minerals. *Bulletin United States Geological Survey*, No. 825, 1931, page 38.

[16] C. H. Bierbaum. The Microcharacter. *Transactions American Society for Steel Treating*, Vol. 18, 1930, pages 1009-1023. Discussion, pages 1023-1025.

Commercial Cathode-ray Tubes

Compiled for *Instruments*. Correct as of Oct. 1, 1937

Twenty-seventh part of "The Cathode-ray Oscillograph and Its Applications" being published serially in *Instruments*. This series began in July 1935 issue.

By RALPH R. BATCHER

Radio engineer; cathode-ray and electronic application specialist, Hollis, L. I., N. Y.

CHARACTERISTICS OF CATHODE-RAY TUBES

Type No.	Screen: Diam. inches	Screen: Decay Time & Color *Note 1*	Tube Length: inches	Deflection Plates: No. of Pairs	Deflection Plates: Leads *Note 2*	Vacuum *Note 3*	Control Voltages: Max. anode volts E_a	Control Voltages: Focus electrode volts	Control Voltages: Control grid Volts at cutoff	Filament: Volts	Filament: Amps. *Note 4*	Base Type *Note 5*	Connections *Note 6*	Deflection Sensitivity: First plates *Note 7*	Deflection Sensitivity: Second plates	Deflection Sensitivity: Comp. Sensitivity *Note 8*	Notes
ALLEN B. DUMONT LABORATORIES																	
24-XH	2	N	7.6	2	C	Hard	600	20% of E_a	—60	6.3	0.8	Octal	i	159	182	284	
34-XH	3	N	11.5	2	C	Hard	1500	25% of E_a	—60	2.5	2.1	7M	d	100	100	67	
54-XH	5	N,W	15.5	2	C	Hard	3000	25% of E_a	—60	2.5	2.1	7M	d	112	112	38	
54-SH	5	X,W	15.5	2	S	Hard	2000	25% of E_a	—80	2.5	2.1	5M	d	75	—	37	
94-SH	9	X,W	21.0	2	S	Hard	3000	25% of E_a	—120	2.5	2.1	5M	d	90	—	30	
34	3.5	N	11.5	2	C	Gas	1000	0 to —250	—	.5 to 1	1.2±	6S	—	66	—	66	
34-S	3.5	N	11.5	2	S	Gas	1000	0 to —250	—	.5 to 1	1.2±	6S	—	66	—	66	
54	5	N	15.5	2	C	Gas	2000	0 to —400	—	.5 to 1	1.2±	6M	—	77	—	38	
54-S	5	N	15.5	2	S	Gas	2000	0 to —400	—	.5 to 1	1.2±	6M	—	75	—	38	
94	9	N	21.0	2	C	Gas	2000	0 to —400	—	.5 to 1	1.2±	6M	—	65	—	33	
94-S	9	N	21.0	2	S	Gas	2000	0 to —400	—	.5 to 1	1.2±	6M	—	65	—	33	
54-S-C	5	N	12.7	2	S	Gas	2000	0 to —400	—	.5 to 1	1.2±	6M	—	114	—	57	
94-S-C	9	N	21.0	2	S	Gas	2000	0 to —400	—	.5 to 1	1.2±	6M	—	65	—	33	
22	1.5	N	5.0	1	S	Gas	1000	0 to —250	—	.5 to 1	1.2±	6M	—	510	—	510	
GENERAL ELECTRIC CO.																	
FP 58	7	N	23.0	2	S	Hard	3000	600	—	—	—	—	—	150	80	27	
GENERAL RADIO CO.																	
478 A	5	N	16.5	2	S	Gas	2000	—50 to —100	—	.5 to .6	1.0±	Sp'l	g	100	105	50	9
528 A	7	N	22.0	2	S	Hard	3000	100 to 600	—250	2.5	2.0	Sp'l	f	110	110	35	10
528 R	7	F	22.0	2	S	Hard	3000	100 to 600	—250	2.5	2.0	Sp'l	f	110	110	35	10
687 P_1	5	N	16.5	2	S	Hard	1500	25% of E_a	—40	2.5	2.1	5M	e	75	90	60	11
687 P_2	5	F	16.5	2	S	Hard	1500	25% of E_a	—40	2.5	2.1	5M	e	75	90	60	12
633 P_2	3	N	11.5	2	C	Hard	1000	25% of E_a	—40	2.5	2.1	7M	d	72	76	76	13
635 P_3	3	F	11.5	2	C	Hard	1000	25% of E_a	—40	2.5	2.1	7M	d	72	76	76	14
HYGRADE SYLVANIA CORP.																	
H-7-2	3	N	11.5	2	C	Hard	1200	150 to 250	0 to —35	2.5	2.1	7M	d	95	89	77	
[illegible]	5																
NATIONAL UNION RADIO CORP.																	
2001	0.9	N	4.7	2	C	Hard	500	100	— 90	6.3	0.6	Octal	i	355	255	510	
2002	2	N	7.6	2	C	Hard	600	20% of Ea	— 60	6.3	0.6	Octal	i	220	220	367	
2003	3	N	11.5	2	C	Hard	1200	25% of Ea	— 60	2.5	2.1	7M	d	88	94	77	
RCA RADIOTRON DIV. RCA MFG. CO.																	
903	9	N	20.5	0	0	Hard	7000	25% of E_a	—200	2.5	2.1	6M	a	—	—	—	15, 16
904	5	N	16.5	1	S	Hard	4600	25% of E_a	—160	2.5	2.1	6M	b	360	—	77	15
905	5	N	16.5	2	S	Hard	2000	25% of E_a	— 60	2.5	2.1	5M	e	110	133	67	
906	3	N	11.5	2	C	Hard	1200	25% of E_a	— 60	2.5	2.1	7M	d	88	94	77	
907	5	F	16.5	2	S	Hard	2000	25% of E_a	— 60	2.5	2.1	5M	e	110	133	67	
908	3	F	11.5	2	C	Hard	1200	25% of E_a	— 60	2.5	2.1	7M	d	88	94	77	
909	5	P	16.5	2	S	Hard	2000	25% of E_a	— 60	2.5	2.1	5M	e	110	133	67	
910	3	P	11.5	2	C	Hard	1200	25% of E_a	— 60	2.5	2.1	7M	d	88	94	77	
911	3	N	11.5	2	C	Hard	1200	25% of E_a	— 60	2.5	2.1	7M	d	88	94	77	
913	0.9	N	4.7	2	C	Hard	500	100	— 90	6.3	0.6	Octal	i	355	255	510	
WESTERN ELECTRIC CO.																	
325	4.6	N	16.5	2	S	Hard	5000	—1500	—100	5.0	0.55	Sp'l	h	333	333	67	
326	7.1	N	22.0	2	S	Hard	5000	—1500	—100	5.0	0.55	Sp'l	h	200	200	40	
WESTINGHOUSE E. & M. CO.																	
RC 590	7⅛	N	21¼	0	0	Hard	8000	100 to 1500	—250	2.5	2.0	435	f	—	—	—	16
RC 593	7⅛	N	22⅛	2	S	Hard	8000	100 to 1500	—250	2.5	2.0	435	f	200	200	35	

Note 1. **N** refers to screens having a normal decay period, where the fluorescence lingers for a period of the order of one-twentieth of a second. **F** refers to a screen with a rapid decay period—less than a few microseconds. **P** refers to a screen with persistent characteristics, where spot glows for a portion of a minute after excitation is removed.

X indicates that N, F or P type screens are available as specified by purchaser. **W:** white trace on black (for contrast) available if specified.

Note 2. **C** refers to tubes wherein one plate of each pair of deflection plates is common and is connected internally to the anode.

S refers to tubes with separate leads to each deflection plate.

Note 3. Hard tubes are evacuated to a high degree and focusing is not dependent on internal gas pressure.

Note 4. In gas focused tubes (see column headed "Vacuum") the filament current must be accurately adjusted to secure correct focusing.

Note 5. The designations **M** and **S** refer to medium and small sockets for glass receiving tubes. The numerals refer to the number of holes in the socket.

Note 6. The letters refer to the respective sketch designations in the diagram herewith.

Note 7. These values refer to the deflecting voltage required to give one inch deflection at the maximum rated anode potential E_a (see column headed "Max. anode volts").

Note 8. These values refer to the deflection voltage required to give one inch deflection at an anode potential of one kilovolt.

Note 9. From Von Ardenne Laboratories, Berlin, Germany.

Note 10. Similar to the Westinghouse Type 593 tube.

Note 11. See RCA Type 905.

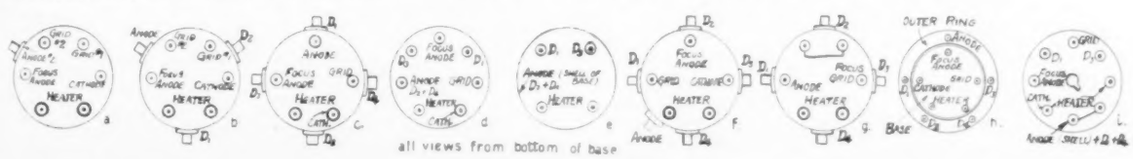
Note 12. See RCA Type 907.

Note 13. See RCA Type 906.

Note 14. See RCA Type 908.

Note 15. This tube has two control or modulation grids.

Note 16. Arranged for magnetic deflection control only. Deflection sensitivity is stated in Ampere-turns per inch deflection.



INSTRUMENTATION FORUM

PROBLEMS — SOLUTIONS — DISCUSSIONS

AUGUST PROBLEM (No. 10)

FORMALDEHYDE GAS DETECTOR

Large chemical laboratories are interested in "the continuous testing of atmospheric air to discover the presence of toxic or harmful amounts of formaldehyde gas. The device should actuate an alarm whenever the determined limit is exceeded. It would also be desirable to record continuously the amount of formaldehyde present."

$5 PRIZE SOLUTION

By WILLIAM WEBER
PHILADELPHIA, PA.

The formaldehyde gas detector herein proposed is simple in construction and the chemical solution used to show the presence of formaldehyde in the atmosphere is well known to chemists. This solution, Schiff's Fuchsin-Aldehyde Reagent, can be bought on the open market in containers already made up. If the inquirer desires to make his own, its formula for preparation is as follows:

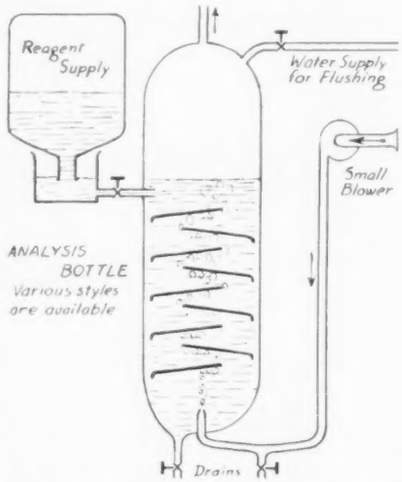
"Dissolve 0.5 g. of pure Fuchsin (prosaniline hydrochloride) in 500ml. of distilled water, and filter solution. Saturate 500ml. of distilled water with sulphur dioxide gas, mix thoroughly with filtered fuchsin solution and allow to stand over night. This produces a practically colorless and very sensitive reagent. When the atmosphere passed through this solution contains a small content of formaldehyde gas the solution will turn a deep pink to a red in color."

The strength of the reagent will depend on how much formaldehyde it must react with before turning color. If made as directed, it will be sensitive to a non-toxic concentration in the atmosphere.

The analysis tube, bottle or column contains the reagent. A continuous sample of the atmosphere is passed through the solution and when this sample contains formaldehyde the solution turns color.

A small blower draws in the continuous sample, drives it to the analysis bottle and forces it through the solution. The valve located below the reagent supply bottle controls the flow of reagent into the analysis bottle. Water may be forced into the analysis bottle to flush it out after some reagent has been turned color. Drains are provided to drain off the reagent after it has been discolored, and to drain off the solution that gets into the air sampling tube when the bottle is initially filled with the reagent.

Operation is as follows: In the morning when the operators come in, the bottle is cleaned by vigorous flushing, after which the water supply valve is turned off, the water drained out of the bottle and both drain-off valves closed. The reagent valve is then opened and the reagent allowed to flow in. (It should cover the nozzle of the analysis bottle a good three inches.) The valve is shut off. The blower is started. Throughout the day the solution in the bottle is



glanced at; when it shows a definite discoloration, large ventilating fans are started and the analyzer flushed out. The procedure discribed at the beginning of this paragraph is then repeated.

This analyzer can be made completely automatic as follows: Magnetically-operated valves can be installed instead of the hand type. A photo-electric cell sensitive to *blue*, and a light source, are installed on opposite sides of the reagent bottle. Or, a blue filter is interposed, so that the cell output will sharply decrease with the appearance of the pink color due to formaldehyde gas present in the atmosphere. The cell is connected to an amplifier, and the amplifier in turn actuates relay switches which will sound off alarms, start ventilation fans, and start also a sequencing timer (driven by a spring-wound motor or by a small electric motor) which closes a series of switches to operate the valves in correct order, flushing and refilling the analysis bottle. The sequencing device can so be constructed that at the end of a few minutes it will stop the ventilating fans.

[EDITOR'S NOTE—These automatic devices do not provide for *recording* the amount of formaldehyde gas present, so that Weber's solution is incomplete. Records can be obtained in two ways:

(1) Analysis column with reagent flowing continuously (no need of flushing) and photocell output continuously recorded. Air-flow-reagent-flow ratio must of course be constant. This can be accomplished by having solution fed by a positive pump driven positively by the same motor that drives the blower.

(2) Use of a time-operation recorder in circuit with timer or with ventilating fans: this kind of record may be the most desirable from the managerial viewpoint. Obvious shortcoming, however, is that recorder does not afford a check on the efficiency of the automatic devices: if these fail to work for a day, that day will show perfect on the chart.

Another way — "registering" rather than "recording" — simply consists in having the photocell operate an ordinary amplifier so as to serve as a check on dependability of the automatic devices.

An illumination recorder, a time-operation recorder or a magnetic counter can be located in a remote office—an advantage in a large plant.]

Problem No. 12 **Subject Index 3.2**

RECORDING SURFACE PROFILE

"In lithography from metal plates, the surface of the plate is 'grained' to give a rough matte finish. Upon the characteristics of the grain depend the quality and press life of the plate.

"Our present methods of measuring our results are microscopic and photomicrographic inspections. Only one quantitative method has been proposed: spreading a known volume of a dye solution and measuring the area it covers. An instrumental method is needed.

"Thinking of the grained surface as more or less uniformly spaced hills and valleys, maximum height about 0.0005" (comparable to a phonograph record), its profile might be measured by 'playing' an area with a needle, and measuring the resulting pitch and volume to obtain frequency and amplitude (number and height of the hills). A more direct method would be to pass a fine point over a straight line of given length, magnify the motion and record it on a chart. Possibly some optical method might be used although the surface variations are large compared with light waves.

"To be adopted, a method should involve the use of commercially available instruments and—if possible—auxiliaries."

Five dollars will be paid for every solution (or critical discussion clearly pointing the way to a solution) which is accepted for publication. Address Instrumentation Forum, 1121 Wolfendale St., Pittsburgh, Pa. Type double-space, on one side of paper. Draw diagram in black ink on separate sheet. Mail before Nov. 15. Solutions and discussions accepted will appear in Dec. 1937 issue.

$5 PRIZE DISCUSSION
By L. RICHARD LANKES
ROCHESTER, N. Y.

Carbon dioxide meters of the continuous recording type are available on the market. This suggests the use of some type of oven or cell through which the contaminated air might be brought and in which the temperature would be raised sufficiently to oxidize or burn the formaldehyde gas completely, leaving CO_2 and water vapor as the products of combustion. This could be accomplished by passing the gases over platinum wires heated electrically to a more or less constant high temperature. In case fairly high percentages of formaldehyde gas are to be dealt with, it may be necessary to supply extra air in order to completely oxidize the formaldehyde. This would, of course, be fresh air brought in from a source where the mixture of gases in it would remain nearly constant. Having been brought through this cell, the gases would now pass through the measuring element of the CO_2 meter from whence they would be discharged by means of an exhaust fan. A calibration of the setup should be readily accomplished by means of standard mixtures. It should not be difficult to provide a set of contacts in conjunction with the indicating element of the meter in order to actuate an alarm circuit when a predetermined limit is reached.

$5 PRIZE DISCUSSION
By W. H. WRIGHT
WILMINGTON, DELAWARE

The reaction between formaldehyde and sodium bisulfite might lend itself to the solution of the problem. It would probably be necessary to prevent oxidation of the bisulfite in the presence of atmospheric oxygen. This may be possible by the use of an oxidation inhibitor such as brucine hydrochloride. A weak sodium bisulfite solution must be used, *e. g.*, a 50ml. solution of 0.001% sodium bisulfite would theoretically absorb the formaldehyde from two liters of 0.005% (by volume) gas. The end of the reaction is indicated by an increase in pH value and in the presence of normal sodium sulfite a strongly alkaline reaction occurs, sufficient to develop a pink color with phenolphthalein indicator.

A possible arrangement of apparatus for continuous detection or recording could be as follows:—A suitable device, electrically operated, by means of solenoid valves, to receive a given quantity of standardized sodium bisulfite solution containing some normal sodium sulfite and indicator, then to start a cycle of absorption from a gas at a constant rate of flow, simultaneously, start the movement of a Warren motor driven pen across a chart, stop the movement of the pen photo-electrically or electrometrically when a color change occurs in the adsorption device, return the pen to the zero setting, stop the absorption cycle, discharge the contents of the absorption device, and restart the cycle. A trip switch could be located at any desired point along the movement of the pen for an alarm indication of excessive formaldehyde in the gas being scrubbed. This arrangement can be patterned somewhat after the devices used to exhibit certain chemical reactions in the museum of the Franklin Institute in Philadelphia.

INSTRUMENTS' BOOK SHELF

The Mechanical Testing of Metals and Alloys. By P. Field Foster. Pitman Publishing Corp., New York, 1936. Cloth, 5½ × 8½ inches, x + 267 pages, Price $3.75.

This is a concise treatment of standardized testing methods and machines with the necessary elementary theory. Adherence to British usage impairs its American usefulness. There are certain important omissions, among them discussions of modern hydraulic machines (only the Amsler is described); modern extensometers such as the Tuckerman optical, Kenyon-Burns wedge, Templin-Selsyn motor, air-gap magnetic, electrical resistance, and modern dial gage extensometers; Microcharacter hardness and Meyer analysis of the Brinell test; tensile impact and high speed impact; and there is no mention of the work of Kuntze on cohesive strength nor of the modern treatment of notch-bend tests. Aside from technological tests, which are not treated in sufficient detail to fill the needs of most inspectors, the material covered has been fairly well handled, though there is hardly a section which will satisfy the exacting testing engineer. The place of the book would seem to be in the library of the young inspector, and should serve his need for a simple introduction to the subject.

—M. Gensamer, *Assistant Professor of Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.* (3)-B-

Electrical Measurements — Precise Comparisons of Standards and Absolute Determination of the Units. By Harvey L. Curtis. (International Series in Physics) McGraw-Hill Book Co., New York, 1937. Cloth, 6¼ × 9¼ inches, xiv + 302 pages. Price $4.00.

In order to convey a true significance of the scope of this book, it is necessary to consider the subtitle: by the author's definition, "Absolute electrical measurements comprise those measurements in which an electrical quantity is determined in terms of two or more other physical quantities." These entities may be electrical, mechanical, magnetic or thermal, or combinations thereof. Hence the attention lavished on the precise determination of length, mass, time, force, energy, and power is comparable with that given to those magnitudes which are recognized as essentially *electrical*: and their fundamental determination is treated in detail consistent with that of current, potential and resistance. Thus, a cursory perusal of the book might lead to the belief that it might well have been entitled without further qualification "Fundamental Standards of Measurement."

The body of the work involves the calculation, design and construction of both absolute and working standards of resistance, voltage, current, capacitance and inductance, together with methods of comparing and combining these standards. One chapter is devoted to the determination of the ratio between the electrostatic and electromagnetic systems of units. A chapter on the history of the electrical units presents a number of interesting facts little known to the electrical fraternity, pointing out, for instance, how local disturbances of the earth's magnetic field due to modern power development and traction systems have rendered obsolete certain standardization methods which at one time were considered as possessing precision of the highest order.

The keynote of the work is comprehended in the one word "precise": and the whole treatment is premised on the assumption that an accuracy of one part in a million is desirable in every type of measurement. This almost astronomical precision is, of course, far beyond the requirements of any industrial or commercial measurement; but in the work of the modern physicist and in the establishment of the values of the electrical units, every additional significant digit of legitimate origin is welcomed.

The text is elucidated where necessary by carefully prepared diagrams and line drawings, a few halftones being presented to show specific types of standard instruments and accessories; the total number of illustrations being sixty-six. Suitably placed as footnotes throughout the work are more than one hundred bibliographical references to authoritative publications.

A thorough understanding of this book requires a working knowledge of higher mathematics; and its principal appeal should be to the teacher and the advanced student of electrical science, as well as to the practicing laboratorian. Considering the involved nature of precise electrical standardization, and the mass of bulletins, reports and other highly technical papers it has heretofore been necessary to study in order to obtain even a reasonable perspective of the science, Dr. Curtis (who is Principal Physicist at the National Bureau of Standards) has performed a commendable task in bringing together and presenting in a readily digestible form the cream of researches, determinations and comparisons extending through a century of electrical engineering.

—P. A. Borden, *Research and Development Engineer, The Bristol Co., Waterbury, Conn.* (4)-B-

Tentative Code of Recommended Practices for Testing and Measuring Air Flow in Exhaust Systems. American Foundrymen's Association, Inc., Chicago, 1936. Paper, 8½ × 11 inches, 12 pages. Price $2.00.

Tentative Code of Recommended Practices for Grinding, Polishing and Buffing Equipment Sanitation. American Foundrymen's Association, Chicago, 1936. Paper, 8½ × 11 inches, 24 pages. Price $2.00.

These two little manuals are proposed standards developed by the A.F.A. Industrial Hygiene Codes Committee and approved by the Association's Board of Directors as tentative codes of recommended practices for the foundry industry. In all, eight fields of work are to be covered, the remaining six being non-ferrous melting, casting cleaning, exhaust systems design, foundry industry code, foundry pertings, and wood-working exhausts. The underlying purpose of the whole series is excellently set forth in the conclusion of the Foreword:

"The Committee, in presenting its recommended practices, is interested in serving the needs of the foundry industry, particularly the smaller foundries where they do not regularly employ an engineering staff. Furthermore, the Committee has as one of its objectives the obtaining of uniformity in the safe guarding of processes and operations.

"It is believed that the engineering data included in these tentative codes of minimum requirements will enable the foundry industry to solve their ventilating problems at minimum cost, consistent with good engineering practice."

Of the eight little books—these two and the six to come—the first one, on Air Flow tests and measurements, will unquestionably prove useful not only to foundries but to all other industrial plants where ventilating systems are now installed or are to be installed. This code enumerates in plain language what instruments to use, where to use each, and how to use each for each kind of determination. It does not pretend to cover the entire field of air flow measurement: only simple methods and simple instruments are dealt with: no space is devoted to recorders or to elaborate permanent installations. It covers the application and testing technique for Pitot tubes, inclined and vertical manometer gages, revolving vane type anemometers and swinging-vane type direct-reading velocity meters. Thirteen figures add greatly to the elucidation of the methods.

The technical committee which prepared this code was composed of the A.F.A.'s regular Hygiene committee augmented for the occasion by L. M. Ellison (Ellison Draft Gage Co.) and M. D. Pugh (Illinois Testing Laboratories), who served as conferees. No

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INSTRUMENTS, published monthly at Pittsburgh, Pa., for October 1st, 1937.

Commonwealth of Pennsylvania, County of Allegheny ss.

Before me, a Notary Public in and for the State and county aforesaid, personally appeared Richard Rimbach, who, having been duly sworn according to law, deposes and says that he is the owner of INSTRUMENTS and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, embodied in section 411, Postal Laws and Regulations, to wit:

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doubt it was the advice of these two men which led to the adoption of one of the most practical codes which this reviewer has ever seen: a code which recognizes that the owners and managers of many small industrial establishments cannot afford to hire mathematical experts and to buy elaborate scientific apparatus.

These little books are apparently reproduced by the offset process: the text—except for headings—appears in typewriter type. Fortunately, it has been split up into many short paragraphs, not hard to read.

—M. F. Behar (2.05)-B-

Reports on Progress in Physics. Volume III (covering the year 1935). Allan Ferguson, General Editor for The Physical Society. The University Press, Cambridge, England, 1937. Cloth, 7 × 10 inches, 394 pages. Price, 20 s.

This periodical (for that is what it is) gets better every year. This year it has nearly forty authors and consequently is rather spotty. The reader will not be disappointed in any single author's contribution, however, and will find the book as a whole a meaty permanent reference. The format being large, each page of solid type has about 520 words—nearly twice as many as in an ordinary textbook page, and the volume—if we deduct the space for bibliographies and illustrations—runs to about 160,000 words. Bear in mind also that most authors have striven to prepare terse correlated abstracts of recent developments rather than verbose essays for non-technical readers.

There being sixteen main divisions, and more than ninety different subjects (counting some which are not given distinct titles) detailed reviews of all of these would make this book review over-lengthy, so we shall give little more than subjects, authors, number of pages, and number of appended references—these last, of course, being what many *Instruments* readers want to know.

General Physics. Surface tension. By R. C. Brown: 8 p., 46 refs.; Elasticity. By H. L. Cox and D. G. Sopwith: 8 p., 50 refs.; Viscosity. By G. Barr: 6 p., 20 refs. An American reviewer feels that the section on elasticity should have referred to the outstanding work on thin-walled cylinders, etc., reported in publications of the N.A.C.A., A.S.M.E., and other American societies and universities.

Fluid Motion. By A. Fage. 15 p., 64 refs. Ten distinct subjects.

The Upper Atmosphere. By S. Chapman and W. C. Price. 23 p., 57 refs. Sixteen sections.

Atomic Physics. By N. Feather. 23 p., 131 refs. About twenty topics.

The Conservation of Energy and Momentum in Elementary Processes. By A. Nunn May. 16 p., 65 refs.

Sound. By E. G. Richardson. 22 p., 78 refs. Divided into six sections, the last, on technology, reporting measurement methods and devices worthy of note.

The Measurement of Noise. By G. W. C. Kaye. 13 p., no bibliography. Divided into ten sections, all of distinct value to *Instruments* readers interested in this field.

Heat. By R. W. Powell. 30 p., nearly 200 refs. Seven sections, diversified in their direct value to *Instruments* readers; some of extreme importance to research workers seeking new methods. Containing however some paragraphs apparently printed without proper editorial revision: The most glaring one describes a new English optical pyrometer with a "novel feature" (brought out by a non-English manufacturer eight years ago and duly reported in *Instruments*); another is devoted to a new book which doesn't seem to rate this honor (even though it is an English book!).

Magnetism. By L. F. Bates. 28 p., 152 refs.

Experimental Electricity and Magnetism: Dielectrics. By L. Hartshorn. 17 p., 62 refs.; Alloys for permanent magnets. By D. A. Oliver, 3 p., 21 refs.; Soft magnetic materials and magnetic measurements. By C. E. Webb. 7 p., 21 refs.; Piezo-electricity. By P. Vigoureux. 5 p., 16 refs.

Electrical Methods of Counting. By C. E. Wynn-Williams. 23 p., 20 refs., several circuit diagrams suggestive of industrial possibilities.

Superconductivity and the Theory of Metals. By A. H. Wilson. 19 p., 22 refs.

Photoelectricity. (Covering the years 1934-1935). By G. A. Boutry. 18 p., 144 refs. To us this appears to be the masterpiece of this book. The author heads the testing laboratory at the Conservatoire National des Arts et Métiers, Paris. He has condensed into a few pages much of his own recent book on photoelectric phenomena. He declares that "No cell can be deemed a perfect or a universal instrument" but he shows also how to obtain an accuracy of 10^{-4}, that is to say, a precision of 10^{-3} in some photometric applications. His two-page introduction deserves memorizing. His article presents some data and points of view not found in English-language or German publications.

Optics. Editor, L. C. Martin: (1) General introduction; (2) Optical theory. By L. C. Martin. 2 p., 3 refs.; (3) Optical instruments (general). By L. C. Martin and B. K. Johnson. 4 p., 17 refs.; (4) Physical optics. By F. Simeon. 3 p., 37 refs.; (5) Ophthalmic optics. By William Swaine. 6 p., 87 refs.; (6) Colour-vision. By W. D. Wright. 3 p., 20 refs.; (7) Glare. By W. S. Stiles. 6 p. (incl. a full-page table of phenomena), 26 refs.; (8) New light-sources; recent developments in electric discharge lamps. By J. T. Randall. 18 p., 11 tables, 13 figs., 10 refs.

X-rays. Editor, G. W. C. Kaye: (1) Production of X-rays. By G. E. Bell. 4 p., 4 refs.; (2) Absorption of X-rays. By I. Backhurst. 2 p., 11 refs.; (3) Scattering of X-rays. By I. Backhurst. 1 p., 6 refs.; (4) Ionization in gases. By I. Backhurst. 2 p., 6 refs.; (5) The energy expended in ionizing air. By W. Binks. 6 p., 35 refs.; (7) Crystal structure of metals and inorganic substances. By W. A. Wood. 5 p., 17 refs.; (8) Crystal structure of organic and biological substances. By J. Thewlis. 5 p., 20 refs.; (9) Radium. By W. E. T. Perry. 3 p., 13 refs.

Spectroscopy. Editor, W. Jevons: (1) Atomic spectra. By M. F. Crawford. 7 p., revised table of nuclear moments, 10 refs.; (2) Astronomical spectroscopy. By A. Hunter. 6 p., 18 refs.; (3) The application of spectroscopy to photochemistry. By R. W. B. Pearse. 6 p., 16 refs.; (4) The rotation-vibration spectra of the lighter hydrocarbons. By W. H. J. Childs. 6 p., 21 refs.

Every reader will like some authors' articles better than others; any reviewer would; this one does. It's not a question of partiality, because the diversity of styles, of treatments, of international scopes and of other personal equations must be evident even to a youthful student totally ignorant of the behind-the-scenes planning of such a compendium. Let it be said, however, that *every* piece of work *now* known to be of *prime* importance disclosed through scientific (and some engineering) media in 1935 (and some earlier, and some of early 1936) is duly reported. No physical research laboratory is completely equipped if it lacks this volume and its two precursors.

—M. F. Behar (12.1)-B-

Directory of Trade Directories. Burns Organization. 203 S. Dearborn St., Chicago. Paper, 6x9 inches, 80 pages. Price $3.00.

The name is descriptive of its contents and purpose, except that the term "trade directories" is used in the broad sense to include trade lists, personnel lists, professional lists, and many annuals, year books, industry catalogs, etc. The book meets a definite need: Trade directories are often difficult to locate unless one knows where to look for them. They are not apparent in the ordinary literature of the industry. If they do not carry advertising, they are not included in the usual publishers' references. They are often obscure and one may not even know they exist.

The book lists more than 400 publications, identifies the publisher of each and describes its contents.

(12.4)-B-

The Mechanical Testing of Metals and Alloys. By P. Field Foster. Pitman Publishing Corp., New York, 1936. Cloth, 5½ × 8½ inches, x + 267 pages. Price $3.75.

This is a concise treatment of standardized testing methods and machines with the necessary elementary theory. Adherence to British usage impairs its

Continued on page 272

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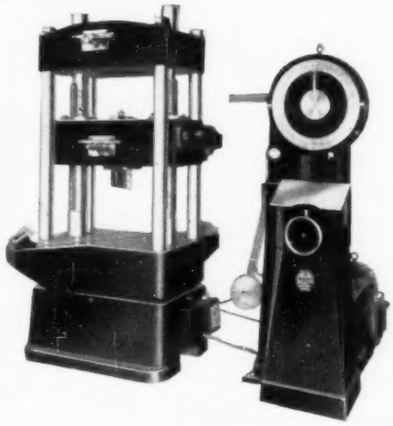

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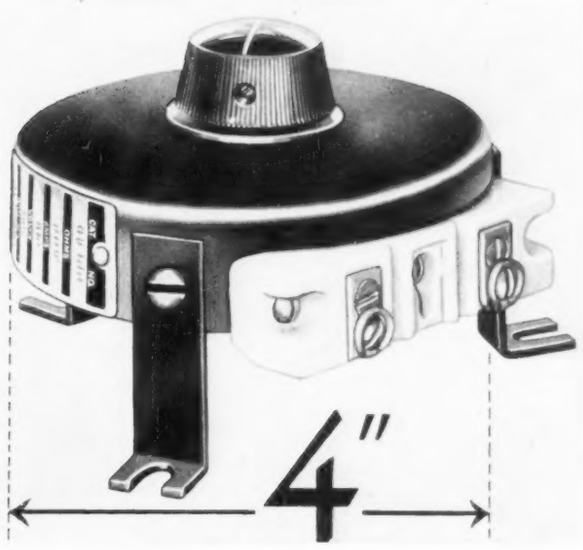

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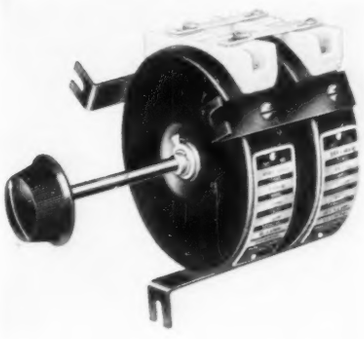

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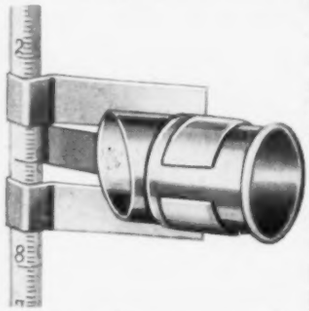

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—M. GENSAMER, *Assistant Professor of Metallurgy, Carnegie Institute of Technology, Pittsburgh, Pa.* (3)-B-

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Telescopes and Range Finders (Die Fernrohre und Entfernungsmesser) by Dr. Albert König. Published by Julius Springer, Berlin, 2nd edition, 1937. Paper, 6½ × 9½ inches, VI + 242 pages. Price 24 RM.

The first edition of this book was published fifteen years ago. In the preface to the first edition the author expressed the feeling that there was an ample literature dealing with the application of telescopes in astronomy and in geodesy and implied that there was less of it dealing with telescopes employed as gunsights and in range finders. For this reason he chose to discuss the application of telescopes to the latter.

The second edition follows the general plan of the first but gives more attention to height finders for anti-aircraft defense and contains a new chapter devoted to the history of the telescope.

This book begins with a statement of some of the laws of image formation. This is followed by a discussion of the properties of the eye and the characteristics of vision. These two sections prepare the way for a presentation of the theory of the telescope in general. This is followed by a short section on micrometers and an extended section on range finders.

All this is done in 236 pages of text. Comprehension of the text is facilitated by 360 illustrations of which two on page 57 are distracting by virtue of their peculiar alignment.

In general, the book treats of a great many things in a very brief way. In view of the brevity of the treatment its value could have been greatly enhanced by a comprehensive bibliography.

The subject matter is well arranged, interestingly presented and because of the long experience of the author in this field it is safe to assume that it is accurate.—W. B. RAYTON, *Head Scientific Bureau, Bausch & Lomb Optical Co., Rochester, N. Y.* (7.1)-B-

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Manual on Geophysical Prospecting with the Magnetometer. By J. WALLACE JOYCE. U. S. Bureau of Mines Publication, March 1937. (Printed by the American Askania Corp., Houston, Texas, under a coöperative agreement with the United States Bureau of Mines). Paper, 6 × 9 inches, xii + 129 pages. Price $1.50

Starting with an elementary discussion of properties of magnets and terrestrial magnetism, this manual presents in detail the theory underlying the operation of vertical and horizontal Askania magnetic balances of the Schmidt pattern. These instruments and their adjustment are described. The factors influencing the accuracy of measurement are quantitatively discussed.

HALT!
Heed Helen's Helpful Hortation
PAGE A9

Beginning with page 58 Joyce gives specific directions for making magnetic surveys. These include corrections to be applied to the data, handling the instruments in the field, calibration and determination of constants, planning the survey and plotting the results. The last chapter treating the interpretation of magnetic data is too sketchy to be of practical value. This is admitted by the author.

The reviewer's experience indicates that magnetic surveying cannot be carried out satisfactorily by men who cannot make all the adjustments on the instruments which do not require shop work. Men with ordinary training in surveying can easily be taught to make the adjustments which, according to the author, should be made by a qualified geophysical laboratory. One of these, the fitting of a new knife edge, is not described in the manual. The other absolutely essential qualification of a successful operator is the ability to adjust the releasing mechanism of the magnetometer. He should also be able to balance the magnet system and to adjust the temperature coefficient.

On page 62 we find the statement: " . . . the least change in the earth's field throughout the day usually occurs from 10 a. m. to 3 p. m. while during the night diurnal changes reach their greatest intensity." This is absolutely wrong, the reverse being true.

The reviewer's experience shows also that a magnetometer operator does not need an assistant, except under unusual circumstances, and that Joyce's estimate of only one or two mile-stations per hour is much too low. Four stations per hour on the average is a better figure.

In general this publication contains a good exposition of the theory of Schmidt balances, and an excellent description of the equipment. It is however recommended more as a source of information than as a manual of field practice.

—VICTOR VACQUIER, *Gulf Research & Development Co. Laboratory, Hamarville, Pa.* (10)-B-